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Instruments

THE MAGAZINE OF *Measurement and Control*

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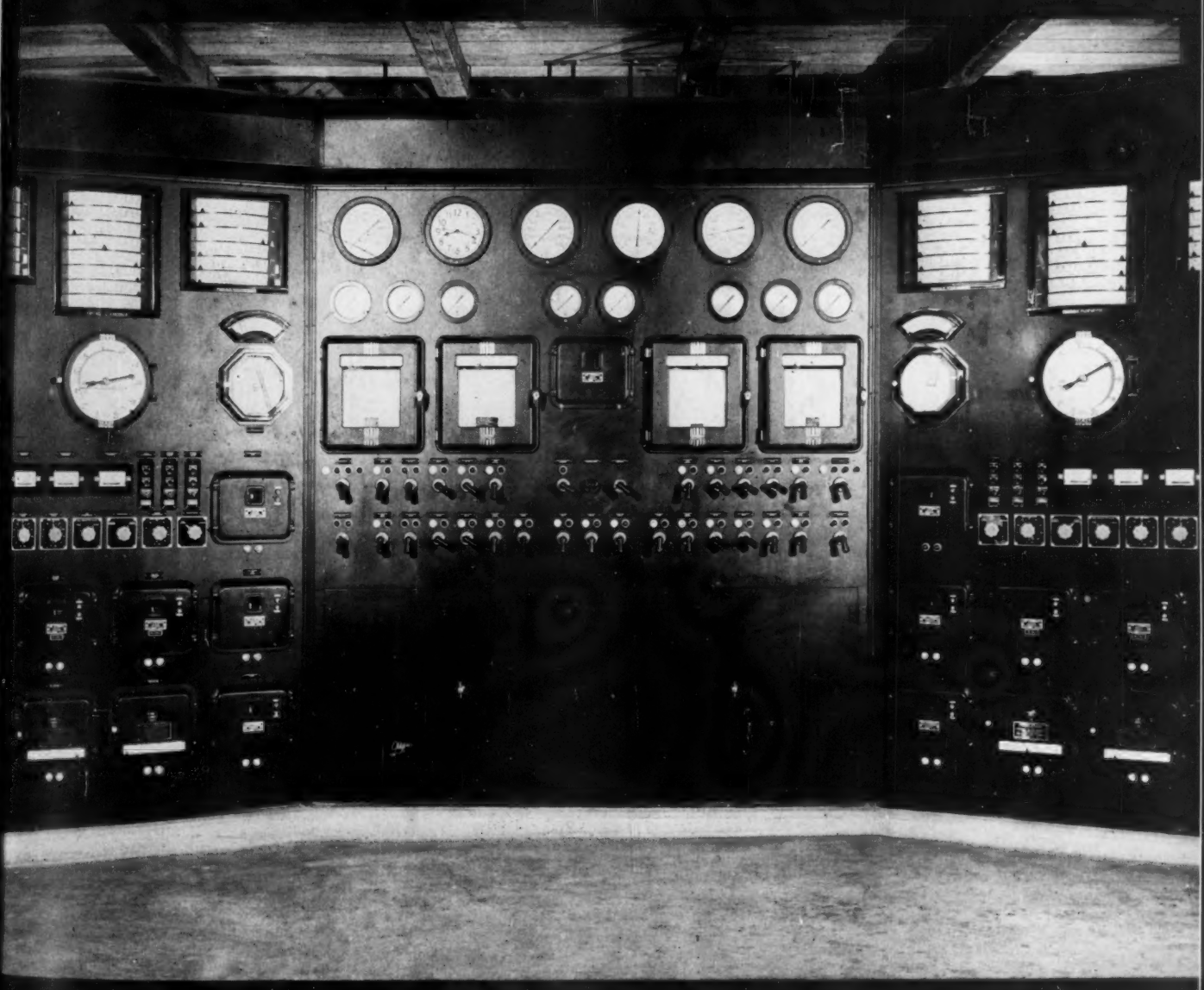

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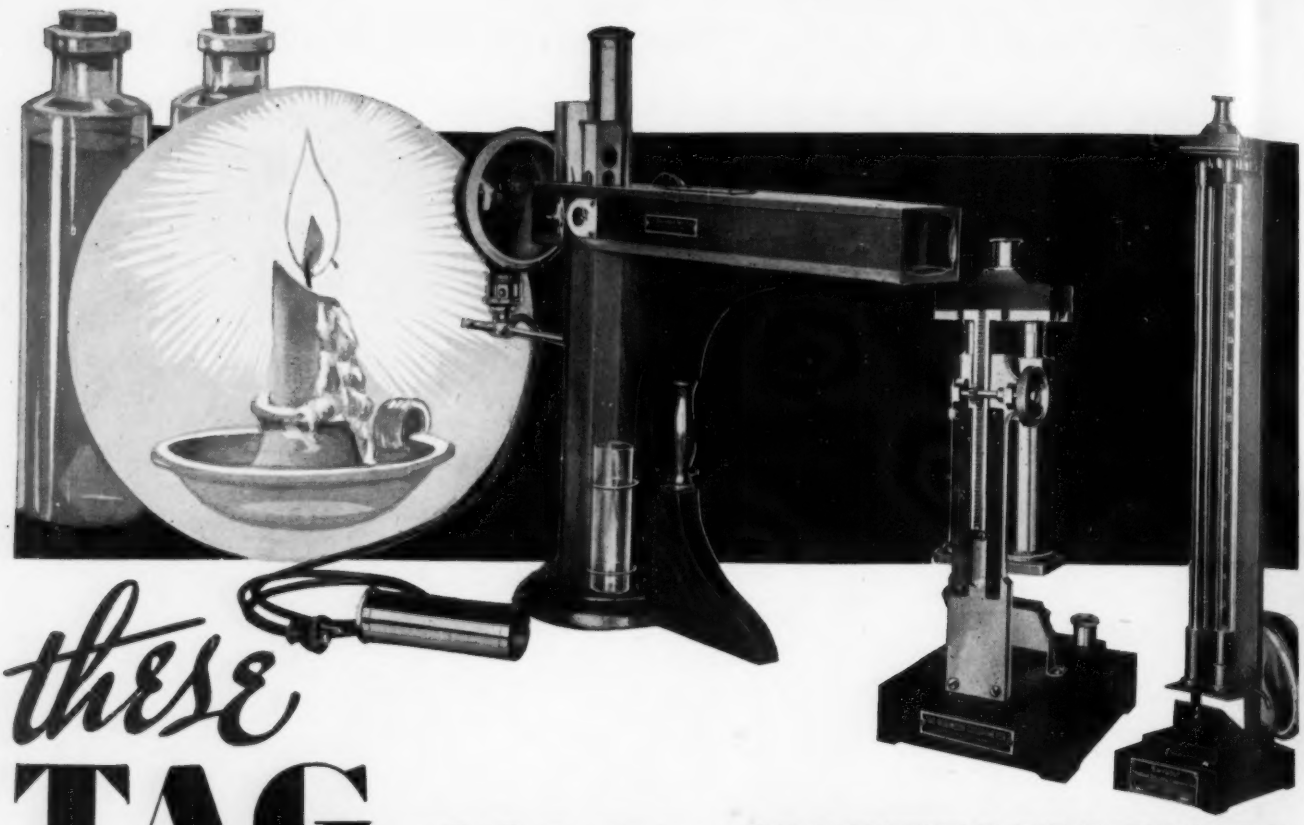

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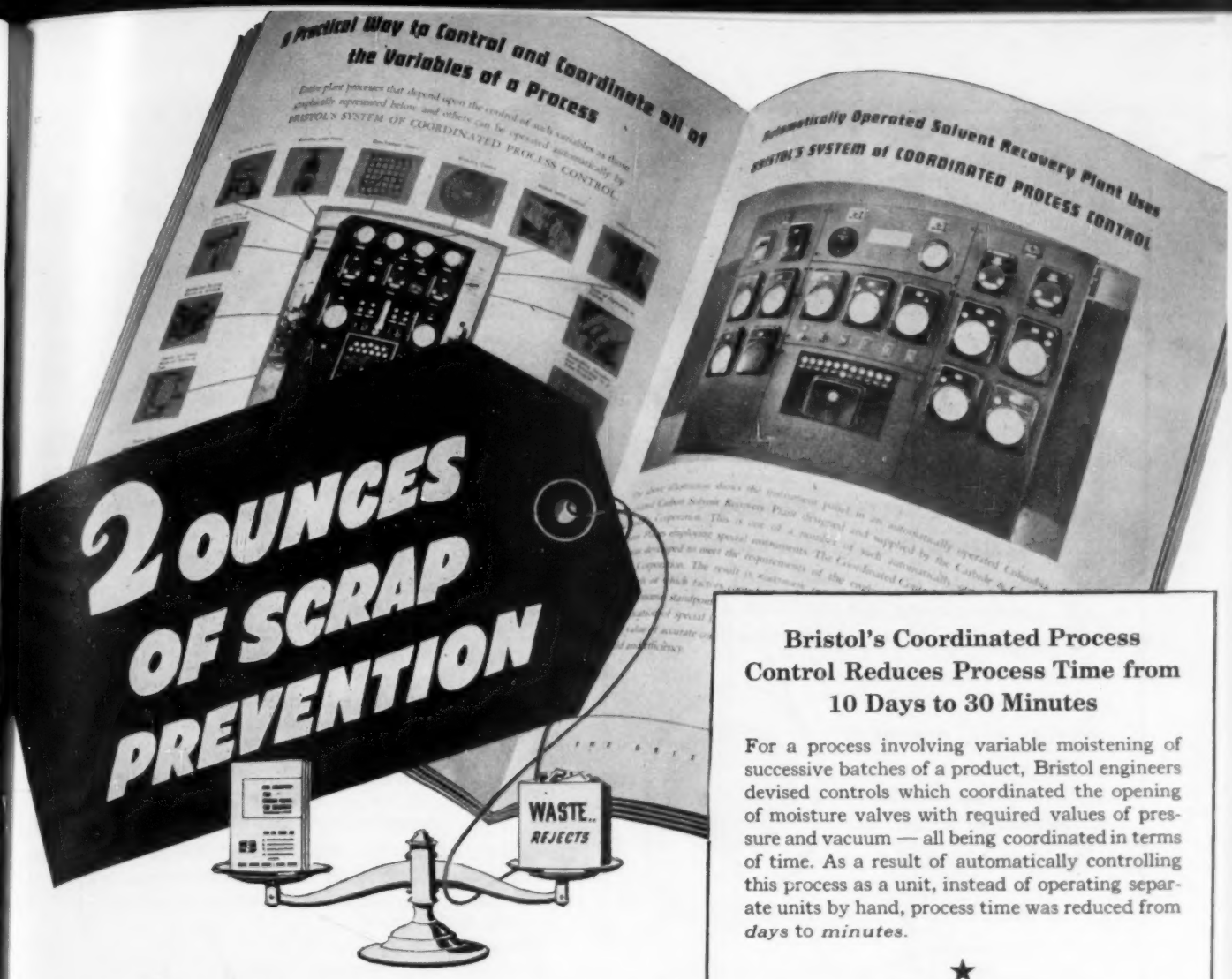
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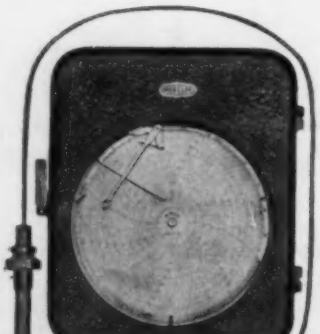

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

The Second A.A.A.S. Conference on Instrumentation

JUST a year ago the announcement and tentative program of the first Conference on Instrumentation under the auspices of the American Association for the Advancement of Science appeared on this page. Afterwards, we devoted our September editorial to a brief account of it and to a list of the fifty-four participants, of whom eighteen (exactly one-third) presented "papers"—or informal talks as things turned out. Of these eighteen talks, four were whipped up into shape for publication and have already been printed in *Instruments*. Of the remaining fourteen, some are being prepared for publication but the others were either "restricted" (in the military sense) or specifically designed for oral presentation and oral discussion only.

At any rate, Science was advanced—by those who prepared papers and by those who discussed them during the sessions (and between!).

We now salute the A.A.A.S. for having decided to hold its research conferences next summer in spite of war-caused difficulties—and for having made Instrumentation the theme of one of the ten conferences for the second year in succession. Extracts from the official notice follow:

A. A. A. S.—Gibson Island Conferences

NEIL E. GORDON, Director
JOHN C. KRANTZ, JR., Assistant Director

This is the sixth summer that special research conferences on chemistry and its allied fields have been held at Gibson Island under the auspices of the American Association for the Advancement of Science. Conferences . . . scheduled:

A. *Frontiers in Petroleum Chemistry.* June 14-18.
B. *Catalysis.* June 21-25.
C. *Organic High Molecular Weight Compounds.* June 28-July 2.
D. *Textiles.* July 5-9.
E. *Strategic Materials.* July 12-16.
F. *Hormones.* July 19-23.
G. *Vitamins.* July 26-30.
H. *Chemical Growth Promoters.* August 2-6.
I. *Corrosion.* August 9-13.
J. *Instrumentation.* John J. Grebe, Chairman; W. G. Brombacher, Vice Chairman.

August 16. W. G. Brombacher and D. P. Johnson: Design and Errors of Precise Laboratory Mercurial Barometers. Carl Frische: Airplane Pilot Controls. W. Mikelson and C. W. Cyphers: Instrumentation for Surface Finish Studies.

August 17. R. D. Wyckoff: Problems in Geophysical Instruments. Ernest A. Capelle: WPB Regulations Relating to Instruments and Controllers. Charles H. Colvin: Problems in Meteorological Instruments.

August 18. H. Ziebolz: Methods and Devices and Flow Measurement and Controls. J. C. Peters: The Problem of Control Valve Characteristics. J. C. Ziegler: Summary of Controller Nomenclature Now in Use.

August 19. Truman S. Gray: Electronics in Measurement and Control. N. B. Nichols: A Mathematical Relation Between the Uncontrolled Response Curve and the Controlled Response Curve Obtained with a Load Change. J. I. Yellott, R. Ackley, and A. Rosenberger: Problems Encountered in Large High-Pressure Valves.

August 20. J. C. Ziegler: Some Investigations of Automatic Process Control. Arthur C. Ruge: The Wire Strain Gage. J. J. Grebe: A New Control Response.

Gibson Island is situated in Chesapeake Bay . . . The conference property . . . consists of a large residence and auxiliary buildings which provide a conference room and accommodations for about 50 men . . . Companies that have made the purchase of this property possible are:

Arthur D. Little, Inc., Cambridge, Mass.; Atlantic Coast Fisheries Co., New York; The Barrett Co., New York; Bausch & Lomb Optical Co., Rochester, N. Y.; The Bell Telephone Laboratories, New York; The Brown Instrument Company, Philadelphia; Campbell Taggart Research Corp., Kansas City, Mo.; Davison Chemical Corp., Baltimore; Distillation Products, Inc., Rochester, N. Y.; Dow Chemical Co., Midland, Mich.; Ethyl Gasoline Corp., New York, N. Y.; Gelatin Products Co., Detroit, Mich.; General Electric Co., Schenectady, N. Y.; B. F. Goodrich Co., Akron, Ohio; Hercules Powder Co., Inc., Wilmington, Del.; Leeds & Northrup, Philadelphia; Merck & Co., Rahway, N. J.; Monsanto Chemical Co., St. Louis, Mo.; National Aniline Division of the Allied Chemical & Dye Corp., Buffalo, N. Y.; The Okonite Co., Passaic, N. J.; Pittsburgh Plate Glass Co., Barberton, Ohio; Research Corp., New York; Shell Development Co., Emeryville, Calif.; Standard Brands, Inc., New York; Standard Oil Co. of California, San Francisco; The Standard Oil Company of Ohio, Cleveland; Standard Oil Development Co., Elizabeth, N. J.; The Texas Co., New York.

. . . Send requests for attendance to the director on or before April 1. Each applicant must state the institution with which he is connected and the type of work in which he is most interested. . . . All requests . . . should be addressed to the director of the conferences, Neil E. Gordon, Chemistry Department, Wayne University, Detroit, Mich.

There probably will be departures from the program: last year four scheduled speakers could not come; two-thirds of the subjects actually presented differed from the announced titles. Conditions are even more difficult this year but Doctors Gordon, Grebe and Brombacher are determined to help ADVANCE SCIENCE—and Science WILL be advanced!

An editor can't please every subscriber in every way. Last year, although we didn't get a single written objection to our "sudden" enthusiasm for the A.A.A.S., two friends voiced what may perhaps have been on the minds of a few subscribers:

1. "So what? Does it help kill Germs-and-Japs? Nothing else matters now!"

2. "So what? Does it give me what I expect for my subscription, namely, help me get ahead?"

The simplest answer to No. 1 is that the name of the association (which I've been gladly helping with my own hard-earned dollars since before it began helping Instrumentation) is AMERICAN Association . . . Many of us members have patents issued or pending on military inventions. Nearly all of us are doing war work full-time or part-time without pay.

The briefest answer to No. 2 is YES! ! ! and several elaborations of this monosyllabic answer have appeared on this page since it has been conducted by

—MFB

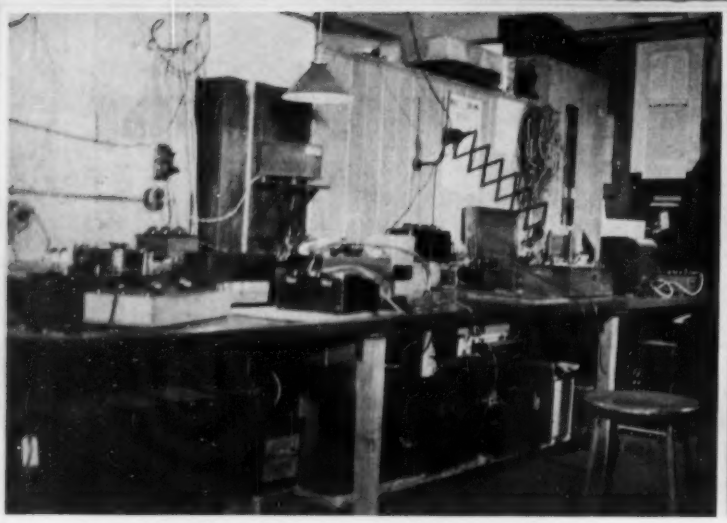


Fig. 1. General view of the Calibration Table.

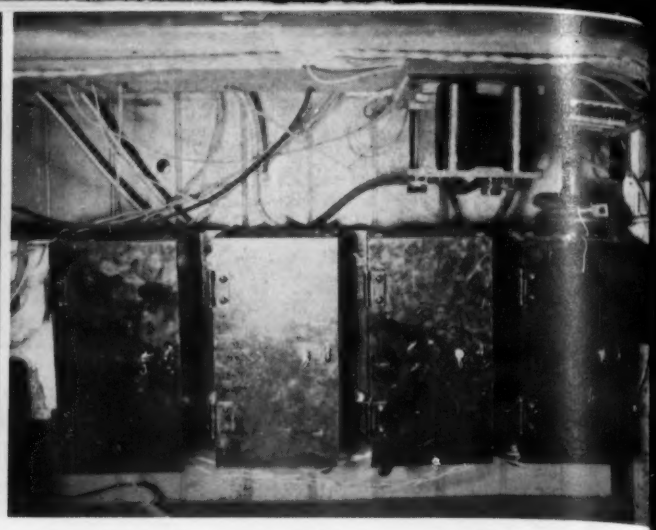


Fig. 2. Heavy current shunts and switches under table.

A Versatile Table for Calibration of Electrical Instruments

By JOHN E. WARREN
200-05 58th Ave., Bayside, L. I., N. Y.

INTRODUCTION

IN a firm engaged in the repair of all makes of electrical instruments, the equipment required for the calibration of the wide variety of instruments to be serviced imposes a difficult problem. The ordinary run of portable instruments range in full-scale value from 0.5 microampere to 150 amperes, and from 1 millivolt to 300 volts; and higher values are frequently encountered. Most of these portable instruments have guaranteed accuracies of 0.25% to 0.5% of full-scale value and laboratory standard types have accuracies of 0.1% of full-scale. In order to be sure of accurate results, the overall accuracy of the equipment must be such that values are correct to 0.05% or better.

The basic equipment therefore, must be a potentiometer and standard cell. The problem then becomes one of setting up a potentiometer and accessory apparatus in such a way that a wide range of current and voltage values can be measured without any loss of time in setting up; also, in consideration of a limited budget, to attain the greatest possible use factor from the least possible number of expensive resistance standards. An indispensable companion of the potentiometer is an accurate Wheatstone Bridge and a Kelvin Bridge for comparing ranges on multi-range instruments.

Ease of manipulation is of prime importance. After all the mechanical work in repairing the moving elements, burnt-out resistors, etc., has been done by skilled instrument repair men, the instruments are calibrated on the potentiometer table. This may be a stumbling-block in a smooth system of work flow unless the calibrating table is always ready to calibrate the average range of instruments encountered in industry.

Fig. 3. Volt-milliamp. control box in the foreground and potentiometer in the background.

GENERAL DESCRIPTION

A heavy wooden table, 18 feet long and 30" high, with a 2" thick hardwood top 30" wide, was installed. At the back of the table a 6" vertical board was secured for mounting the various panels with switches and terminals. To the top of this riser; another piece was secured at right angles, as a sort of hood to protect the switches from the dust. The writer's experience with calibration methods served as a guide in the arrangement of the equipment, switches and controls, in order that they might be conveniently located with a minimum of waste motion. As many of the heavy current shunts and switches as possible were placed out of the way under the table (see Fig. 2), care being exercised that stray fields from such apparatus did not affect the calibration of unshielded d'Arsonval type instruments. The wiring of the apparatus was concealed underneath the table as much as possible.

On the table there were mounted two Wheatstone Bridges, one Kelvin Bridge, two potentiometers (one high-resistance type and one low-resistance type) with their respective accessories.

POWER SUPPLY

The source of supply for the voltage was a 400-volt rack of 25-ampere-hour Edison cells. The current supply consisted of four glass jar type lead cells of 200-ampere-hour capacity arranged to be connected in series for 8 volts or two parallel groups of 4 volts. An auxiliary source of supply of 30-volt Edison cells with taps at every 10 volts was provided for the calibration of instruments below 300 milliamperes and 30 volts.

The source of standardizing current for the low-resistance potentiometer is a 2-volt lead cell which is left on continuously. This is done in order to have the potentiometer available for instant use, and it assures minimum drift. For the high-resistance potentiometer, a source of two dry cells is connected continuously. The drain in either case is extremely low and these supplies have been holding up very well for the last three years.

VOLTAGE CONTROL

The voltage control box consists of 10,000-ohm and 500-ohm potentiometers connected across the line. In series with the arms of these two potentiometers are one 100-ohm, one 0.45-ohm and one 0.25-ohm variable series resistors. The 0.45-ohm variable resistor is obtained by shunting a 3000-ohm rheostat so that it gives a variation between 32.2 and 32.65 ohms. The 0.25-ohm variable resistor is obtained by shunting a 10-ohm rheostat. This combination gives very smooth control when used to control current or voltage within the range of the combination shunt and volt box. Fig. 4 is a schematic diagram of the rheostat values and connections.

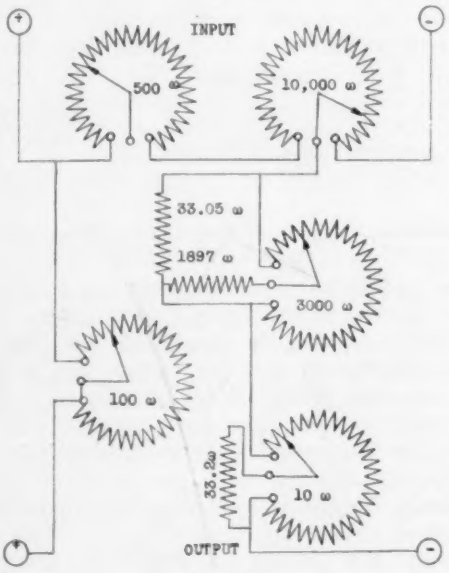


Fig. 4.

CURRENT CONTROL

The current control was obtained by means of a combination of slider rheostats and a cage of grids. The slider rheostats are so arranged that they can be connected all in series or put in parallel one at a time, thus increasing the capacity and the effective control of the group. The higher-resistance slider rheostats in parallel with the low-resistance rheostats give a very smooth vernier control. The rheostats were designed to operate on the 8-volt supply. In selecting the slider rheostats, units of higher resistance than required were selected because of the smaller size of wire or ribbon used in winding these units. This gave a finer adjustment per inch movement of the slider. These slider rheostats were shunted to the proper value by resistors which shunted approximately one-half of the total current from the rheostat. In series with each unit, a resistor was adjusted to limit the current and allow the use of the full length of the rheostat

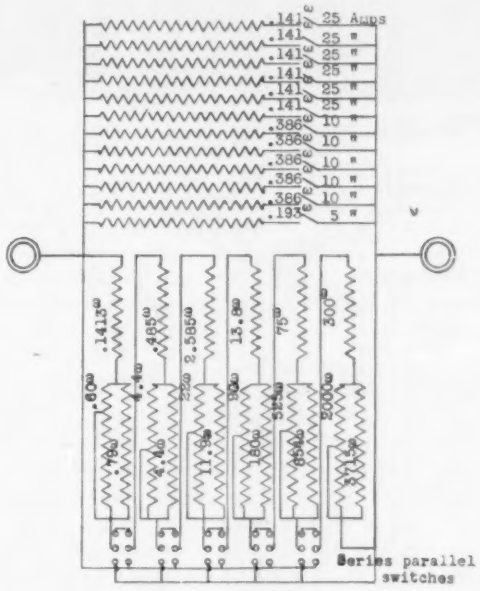


Fig. 5. Current control box.

when connected in the parallel circuit. Each unit was equipped with a screw-drive, the control knob protruding in front of the panel. The grids were wound on mica-insulated steel strips which were mounted in a cage. The units in the cage were such that even steps of 5 amperes, up to 195 amperes, could be obtained and were adjusted for operating off the 4-volt supply. The grids are made available in the circuit by connecting them in parallel with the slider rheostats. Each grid has an individual toggle switch and can be readily cut in or out of the circuit. Fig. 5 is a circuit diagram showing the values which give close-to-ideal results in this particular case.

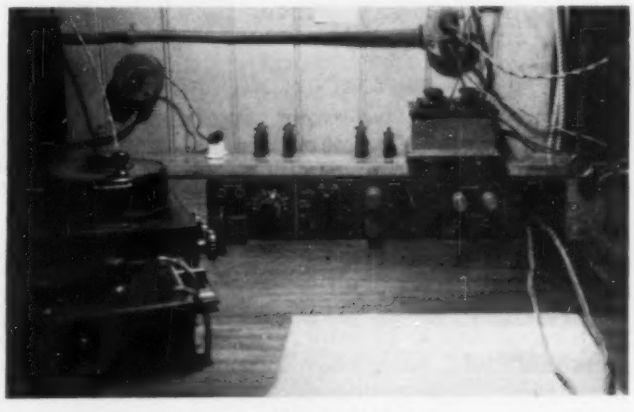


Fig. 6. Control Panels.

In computing the values of the low-resistance grids which give the 25-amp. steps, the resistance of switch contacts, leads, standard resistors, average instrument resistance and internal battery resistance had to be taken into consideration. Six 25-amp. units, five 10-amp. units and one 5-amp. grid make it possible to get various combinations of even increments of current with only slight adjustment of the slider rheostats. Some economy of this arrangement was found in the difference in cost between good 25-amp. and comparable 50-amp. tumbler switches. The arrangement of the complete

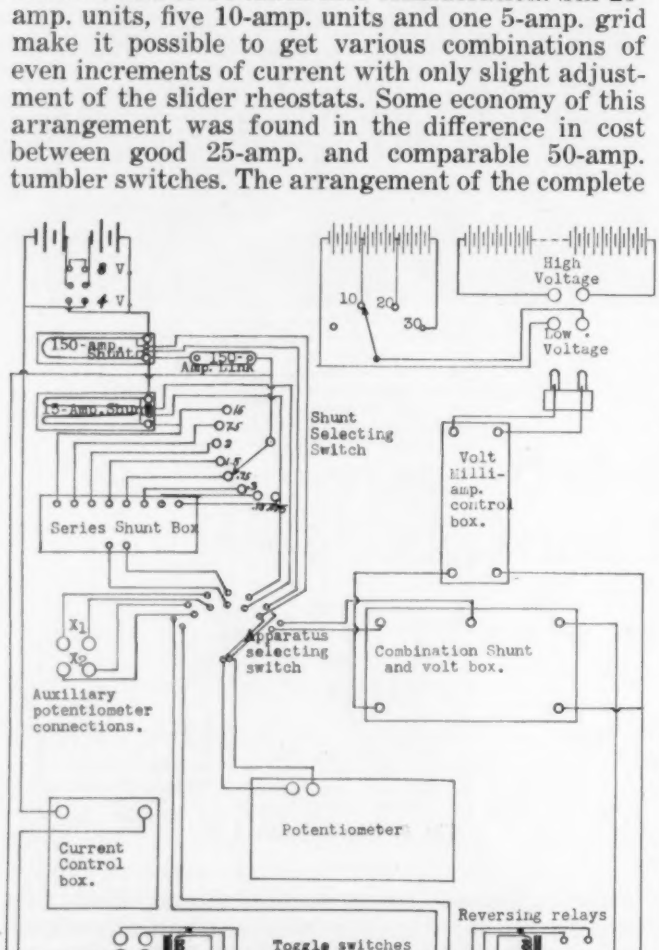


Fig. 7. Simplified Schematic Diagram of Calibration Table Wiring for One Potentiometer.

unit consisted in mounting two decks of three rheostats each on top of the grid cage. The switches and rheostat knobs were operated from the front of a panel mounted on the cage. The unit complete was just large enough to slip under the table, making it convenient to reach for the rheostat knobs and the tumbler switches.

SWITCHING METHOD

By means of a two-prong plug, it is possible to select either the 400-volt source or the 30-volt supply. On the same panel, steps of 10 volts can be selected by means of a switch from the 30-volt supply. In instances where a voltage source lower than 10 volts is required, it is possible to connect a 1½-volt dry cell to the two prongs of the plug.

A 15-amp. switch was provided for selecting the various standard resistors for current measurements from 0.3 ampere up to and including 15 amperes. A heavy copper link was provided for making the next connection for the next step which is a 150-amp. shunt. This was resorted to because of the difference in cost between a 150-amp. switch and a 15-amp. switch.

The switch for selecting the potential terminals of the various resistance standards had to be absolutely free from parasitic e.m.f.'s as well as having its two decks well insulated from each other. By means of this switch, the potentiometer could be connected across any of its standard resistors. One switch position connected the potentiometer across the binding posts where the potential supplies were terminated for millivoltmeter calibration. Two switch positions were reserved for the intercomparison of standard resistors or checking of auxiliary e.m.f.'s, such as standard cells or thermocouples. These two switch positions were terminated in four binding posts on the output panel.

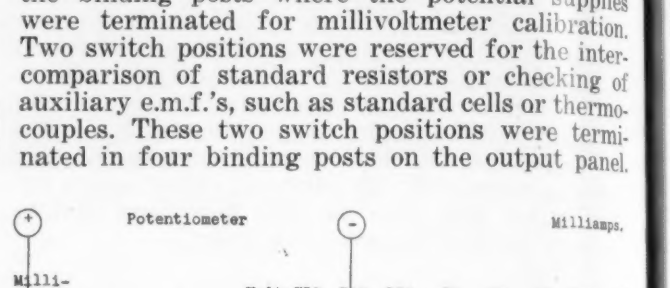


Fig. 8. Schematic Diagram of Combination Shunt and Volt Box.

Another switch position connects the potentiometer across a combination shunt and volt box described later in this article. By means of this same switch the potentiometer can be connected to a series shunt, ranging from 0.3 to 7.5 amperes. Separate switch positions are used for connecting the potentiometer to the potential terminals of the 15-amp. and 150-amp. shunts.

150-amp. magnetic contactors were selected for closing and reversing the current circuits, and 15-amp. relays for closing and reversing the potential circuit. These magnetic contactors and relays were controlled by single-pole three-position tumbler switches which operate the relays on 110-volt direct current (laboratory commercial supply). A neutral position on each tumbler switch opens its circuit. These two switches were housed in a small Bakelite box, with a flexible cable offering the convenience of controlling the supplies from different vantage points on the table. In wattmeter calibration, both current and voltage can be reversed simply by throwing the two tumbler switches to the opposite side.

COMBINATION SHUNT AND VOLT BOX

For the selection of various low-range shunts and different taps on a volt box, the writer designed a combination shunt and volt box wherein the same set of accurate resistors serves both purposes. By means of a highly insulated 2-deck ceramic switch, it is possible to switch this set of series resistors in series or across the instrument being calibrated. A series of carefully constructed resistors adjusted to 0.02% was procured from a

reputable firm in the United States. This set of resistors was mounted on a hard rubber ring which encircled a 2-deck 16-point highly insulated ceramic switch. The resistors were all connected in series and the junctions between resistors were connected to the two decks of the switch. The arm on one deck carries the connection to the potentiometer and the arm of the other deck carries the connection to the supply, when used as a shunt box. When this set of resistors is used as a volt box, only the potentiometer connection is used on this switch to select the potentiometer tap on the multiplier. The switches were mounted on ⅜" hard rubber panels and the input and the output terminated into large ceramic posts. The resistance of the series combination is 10,000 ohms, providing a range from 15 microamperes to 300 milliamperes and from 3 volts to 400 volts. The limit of the voltage range is determined by the power-dissipating capacity of the resistors. Since these standard resistors were of a two-watt rating, voltages higher than 400 volts would begin to exceed the rating of these resistors. See Fig. 8 for circuit diagram of combination shunt and volt box.

The economic advantage of this arrangement lies in the fact that one set of standard resistors can be used for two purposes. By means of two switches, nineteen ranges are made available: eleven current ranges and eight volt ranges. This combination shunt and volt box is so positioned that low-resistance electrodynamic voltmeters which must be used with calibrated leads can be conveniently connected directly across the supply terminals of the unit.

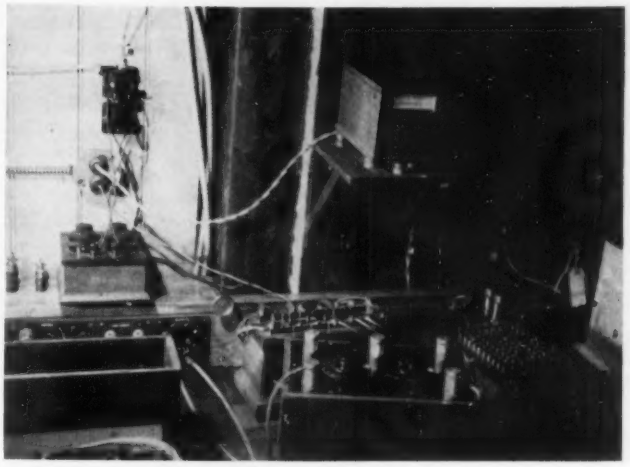


Fig. 9. Combination shunt and volt box in the center foreground.

VIBRATIONLESS SUPPORT FOR GALVANOMETERS

In a city like New York, it is relatively difficult to find a solid support in its tall buildings suitable for mounting a very sensitive galvanometer. In this particular instance the problem consisted in mounting a very sensitive galvanometer on the 15th floor of a building which stood on a busy street and under which tube trains ran frequently. One of the columns which went down through the center of the building to the foundation was selected. Two shelf supports of angle iron in the form of inverted trusses were secured to it by long bolts holding the trusses together on each side of the column. The shelf was made of 1" pine with trusses underneath each board for elimination of secondary vibration in the shelf. When complete, each shelf measured 30" along the column side and extended 2 feet from each side of the column. See Fig. 10.

On each shelf the light source, mirrors and galvanometer were all mounted. See Figs. 10 and 11. The galvanometer and light source were so arranged with respect to each other so that the heat of the lamp in the light source did not affect the galvanometer. The galvanometer was mounted at the extreme end of the shelf, about 20" away from the column. The light source was mounted diagonally on the other corner of the shelf. The light beam proceeds from the light source to a small mirror at the edge of the shelf facing the light source and the galvanometer, by means of which the light beam is reflected to the galvanometer. The light beam from the galvanometer mirror was directed to a 1" × 10" mirror which deflects the light beam on to the table top.

The length of the light beam from the galvanometer mirror to the scale on the table top is two meters. The scale consists of a piece of ruled ground glass mounted upright, back of which a mirror is mounted at a 45° angle, deflecting the light beam

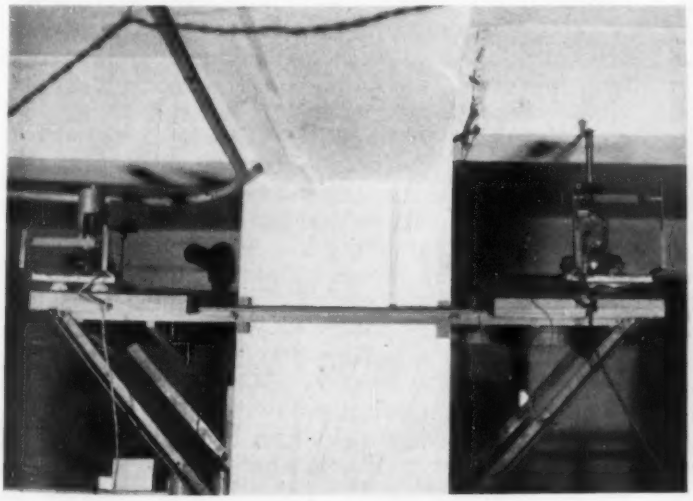


Fig. 10. Construction of shelf.

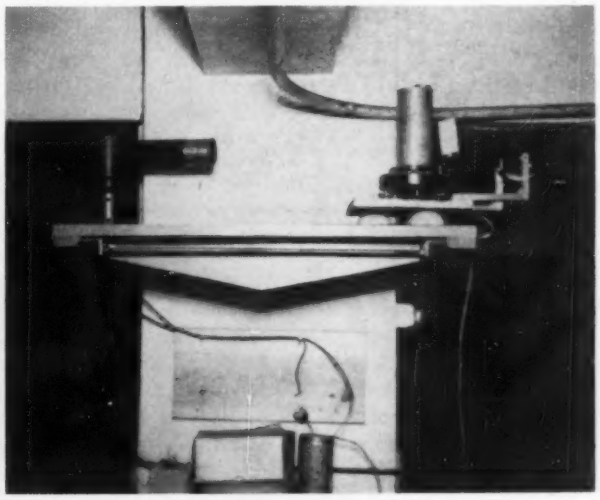


Fig. 11. Galvanometer mounting and optical system.

from the table top on to the scale. The advantage of this arrangement lies in the ease with which one can glance from the instrument indication to the galvanometer balance and back to the instrument indication. Zero setting can be made by moving the scale until the scale zero is lined up with the hair-line in the light beam.

When the galvanometer was mounted directly on the shelf with nothing to absorb the vibration, an oscillation of 30-cm. amplitude was observed at the end of the 2-meter beam of light. The cost of a Julius suspension being prohibitive. Experiments were conducted to mount the galvanometer on some form of absorption material to absorb the

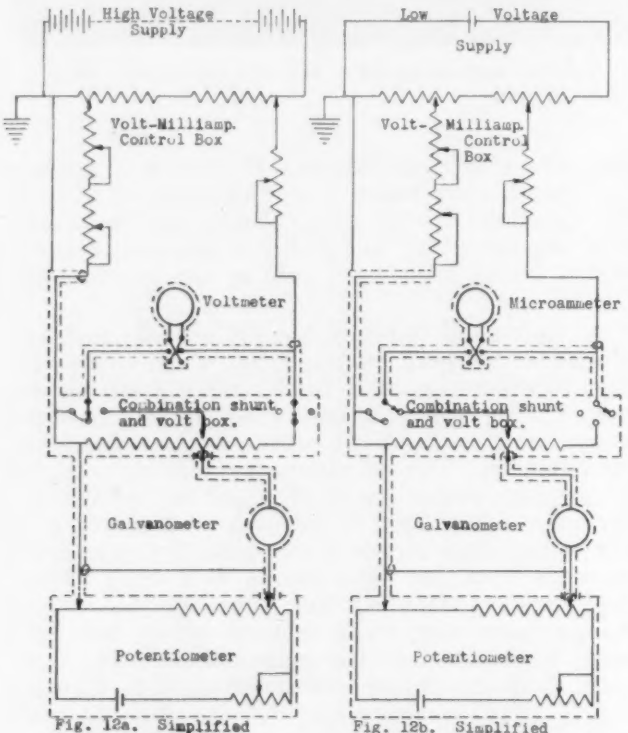


Fig. 12a. Simplified Schematic diagram of shielding circuit when calibrating a voltmeter.

Fig. 12b. Simplified schematic diagram of shielding circuit when calibrating a microammeter.

Fig. 12

building vibration. The galvanometer was set on a heavy lead plate which in turn was set on cork, floated on oil, set on rubber balls, sponge rubber, etc. The final solution involved the use of a lead plate of such weight that, when combined with the weight of the galvanometer, it compressed three sponge rubber balls to one-tenth of their total compressibility. As a result, the total oscillation at the end of the light beam was reduced from 30 cm. to a half a centimeter maximum when train traffic was at its worst.

POTENTIOMETER SHIELDING CIRCUIT

Due to leakage currents, considerable trouble was experienced when calibrating instruments of the order of half a microampere. Solution of this problem resolved itself into two possibilities: either shielding the circuit or trying to insulate it. Insulation alone proved insufficient after some experimentation, because the humidity in New York and vicinity in summer time caused moisture to condense on the surfaces and promote leakage paths. The problem was finally solved by a combination of both insulation and shielding. A fine grade of highly insulated copper wire (duck wire) was secured through the courtesy of the telephone company. This was shielded by covering it with a wire-woven braid. One of the difficulties encountered in wiring with this combination was a leakage path formed from the shield to the conductor at the ends, where the conductor was terminated. Investigation disclosed that the cause was a fine spray produced by a soldering flux when soldering. This spray coated the rubber insulation between conductor and shield and produced a leakage path. This was remedied by cleaning and drying out the lead ends and dipping them in ceresin.

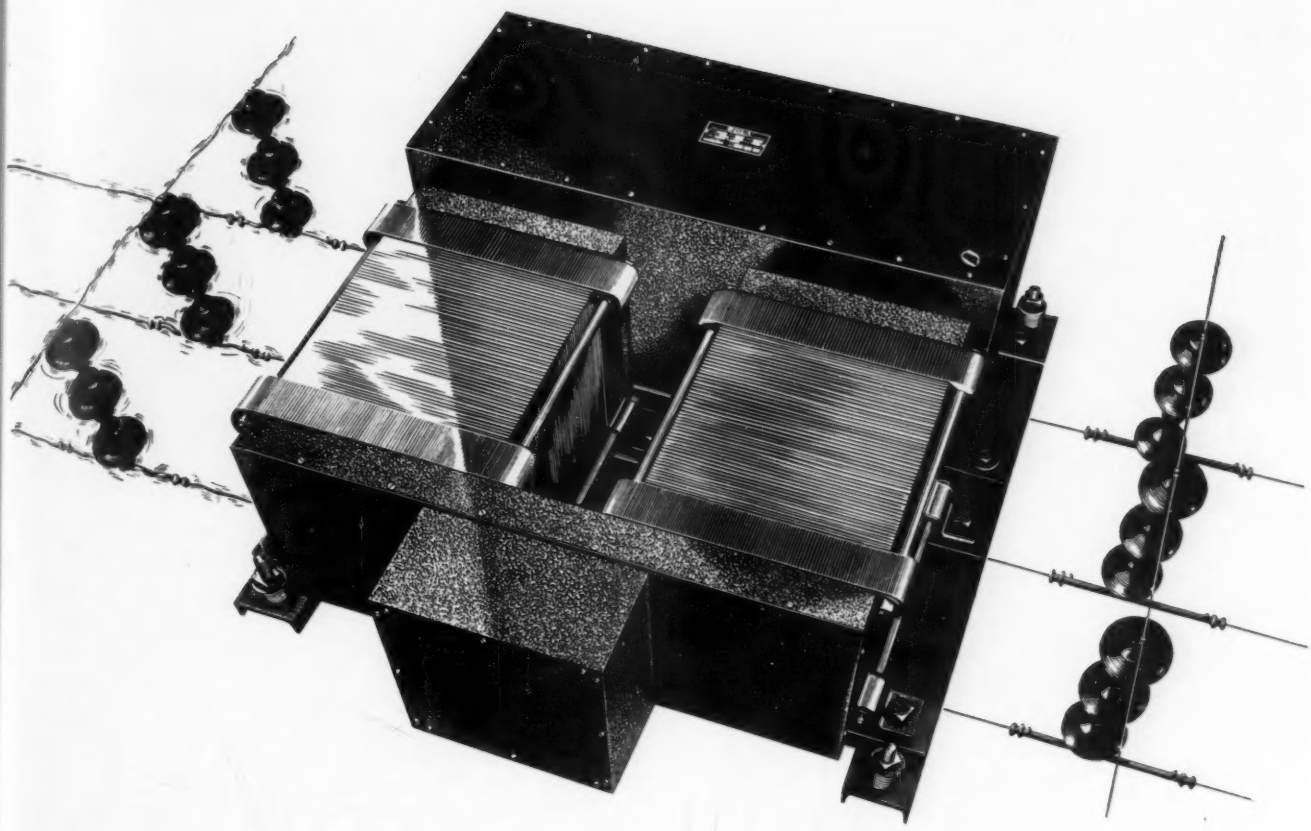
The shielding circuit consisted basically of mounting the galvanometer, potentiometer and potentiometer current supply, standard cell, combination shunt and volt box on metal plates. The galvanometer shielding circuit was connected to the positive side of the unknown e.m.f. binding post of the potentiometer. The shields of the remaining circuit elements were connected together by means of shielded braid on the wires used to interconnect the various elements. This shielding circuit was grounded to the positive side of the rheostat box. In mounting the various units on the metal plates, the units were insulated from the plate by standing the elements on short hard rubber posts. Provisions were made for mounting the instrument being calibrated on a similar mounting and using a pair of shielded leads. In Figs. 12a and 12b, shielding is represented by broken lines.

CALIBRATING A WATTMETER

In order to show the flexibility of this arrangement, the procedure in calibrating a wattmeter will be used as an illustration. A second high-resistance potentiometer is somewhat similarly equipped for voltmeter and milliameter calibration. In calibrating a wattmeter, the voltage is held at constant value with this other potentiometer. This is accomplished by connecting the second potentiometer to the potentiometer binding posts of the combination shunt and volt box of the first low-resistance potentiometer. One dial of the combination shunt and volt box is set on volts and the other is set on a voltage range to be measured. The potential-selecting plug is inserted into the high-voltage supply and the output of the voltage control box is put through the controls of the high-resistance potentiometer. This arrangement facilitates the reversal of voltage at the same potentiometer on which the current is being calibrated. The actual voltage control, however, is obtained at the controls of the high-resistance potentiometer, thus enabling the man observing the potential balance to adjust the voltage when it drifts off. The man calibrating the wattmeter at the low-resistance potentiometer sets the pointer of the wattmeter on the point being calibrated by controlling his current supply. Then he measures the current flow by measuring the voltage drop across one of the standard resistors, by balancing the potentiometer. This is accomplished by first selecting the standard resistor of proper value to carry the current, by means of the standard resistor selecting switch and setting the apparatus selecting switch on to the series shunt box, or the 15-amp. shunt, whatever the range may be, thus connecting the potentiometer across the

(Continued on page 151)

Industry steadies its "nerves"



FACED with production schedules that have no precedent in history, American industry finds the fluctuating voltages of its over-loaded power lines wholly inadequate to meet the "deadly" precision demanded for total war.

Vital "nerve centers" of production lines are geared for precise performance when operated at specific line voltages. Any variation from these rated values, and there are many these days, may well mean lagging production schedules and a noticeable lack of uniformity in products.

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Here is the first batch of **SHOP KINKS** from *Instruments* Readers

SEE PAGE 179

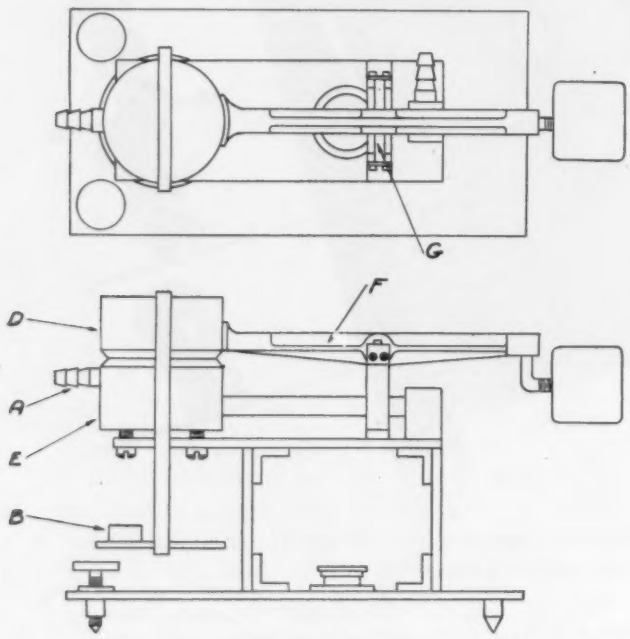
Testing Scale for Pressure Instruments to 3″ Water

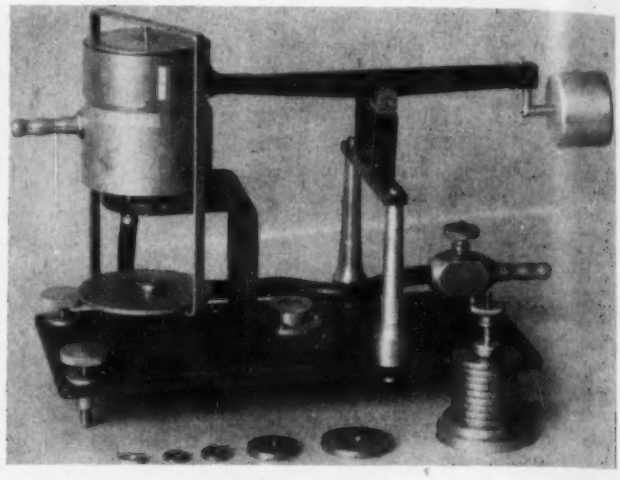
By HERBERT ZIEBOLZ
Askania Regulator Co., Chicago, Ill.

ORIGINALLY developed for our testing laboratory, the testing scale described in the ensuing paragraphs could be, we believe, a valuable tool to manufacturers or service departments working with low-pressure gages.

Description — The instrument eliminates diaphragms and springs and thus avoids completely their characteristics which have a tendency to change with time. It employs a "null" principle.

Air is supplied through connection *A* to the lower *E* of two cylindrically shaped cups *D* and *E*.





Cup *E* is stationary while *D* is attached to balance lever *F* supported by knife edge *G*.

As calibrated weights *B* are placed on the scale, the pressure building up inside of the cups, acting on the area of the cylinder, balances the weight as an increase of the pressure increases the distance between both cups and thus relieves the pressure.

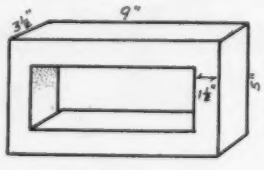
The unit was found to be particularly useful for recalibrating low-pressure flow and pressure gages in the field, but it can be used also in production testing as no experience is needed for adjusting pressure levels.

Range—The minimum pressure for which the shown unit is regularly used is 1/100″ of water (0.0186 mm. mercury), and its maximum range is 4″. Other ranges can be obtained by using other cup dimensions.

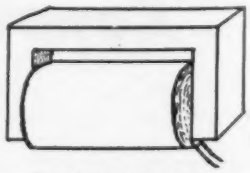
Home-made Testing Transformer

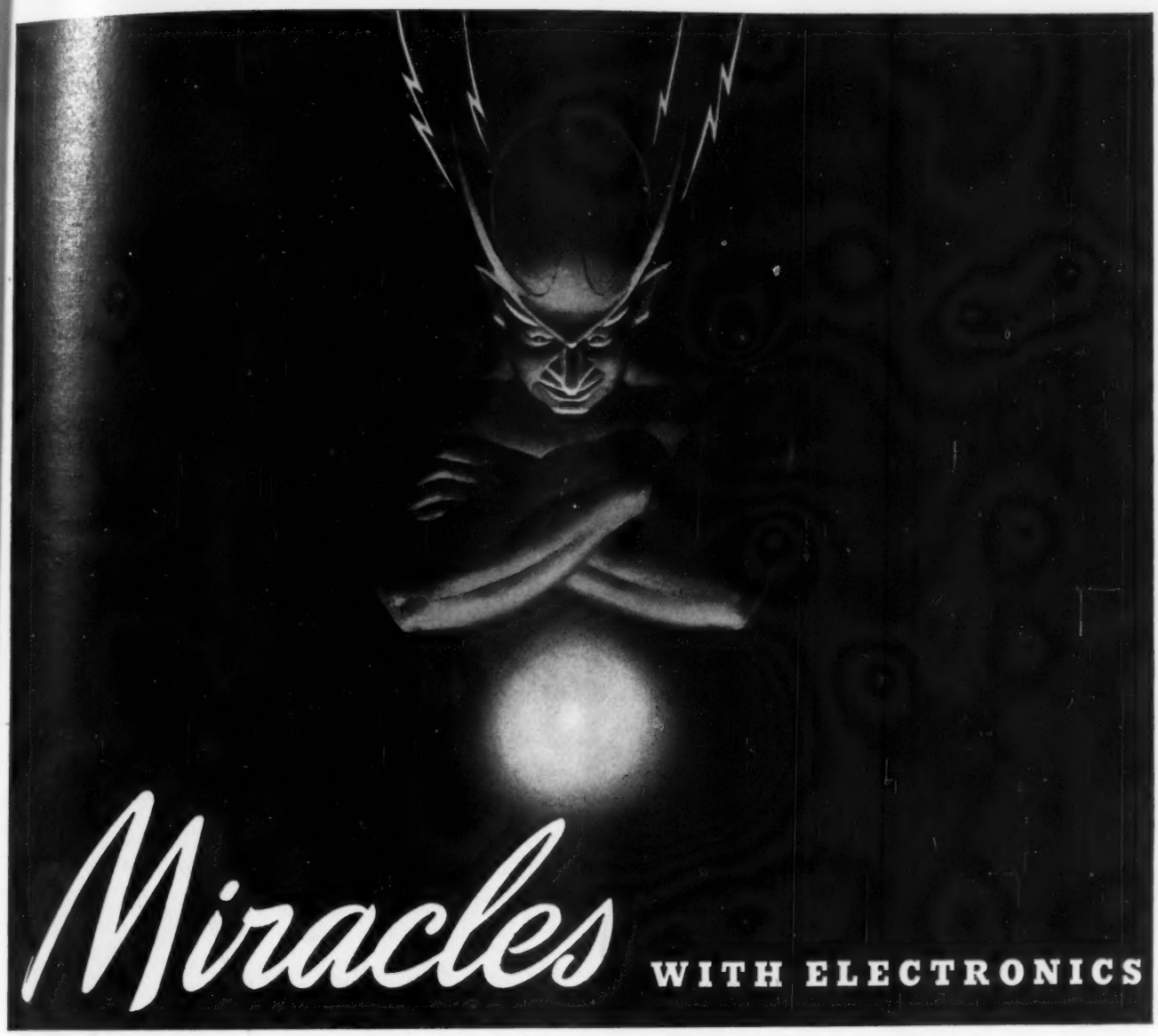
By CHARLES E. DIEHL
Master Mechanic, Utah Idaho Sugar Co., Spanish Fork, Utah

THE transformer here described has been built and used in several shops where I have been located. It has been used for a-c. relay, a-c. or d-c. thermal overload and a-c. magnetic overload element testing, all currents up to 500 amperes. It is rated at 1 kw. continuous operation. Primary is wound for 115 volts at ½ turn per volt and no secondary. This design makes it infinitely flexible both as to current variation desired and as to voltages delivered. The user wraps twice as many turns around the open core leg as he desires volts delivered, allowing one turn for each half-volt to be produced. The wire size used depends on the current desired. Allow 500 circular mills cross-section to each ampere to be used in continuous operation. Higher currents may be used for short times with smaller wire. For high-current work, four turns of 4/0 welding cable is good up to 250 amperes and two of the same in parallel for 500 amperes. Odd voltages needed for testing can be obtained with small wire with the voltage limited only by the number of turns the operator is willing to lace through the opening. Hook-up for high-current work is made with a rheostat or a lamp bank in series with the primary and a clamp-on type ammeter in the applied secondary. However the trans-



Assembled Core


Finished Coil



ELECTRONICS bids fair to revolutionize our every day living after the war. When Brown and Minneapolis-Honeywell placed experience and manufacturing resources at the call of our government, the result of several years of research in Electronics was immediately applied to instruments—for Testing airplanes in flight—for Controlling production of high octane gasoline—for Treatment of special alloy steels for tanks, guns and armor plate—for Manufacture of synthetic rubber—and for many other purposes entering directly into the war effort.

Extending this peacetime experience to the technique of war, will bear fruit when Peace comes again, in startling new developments in the Electronic control of industrial processes—busily engaged in peacetime production.

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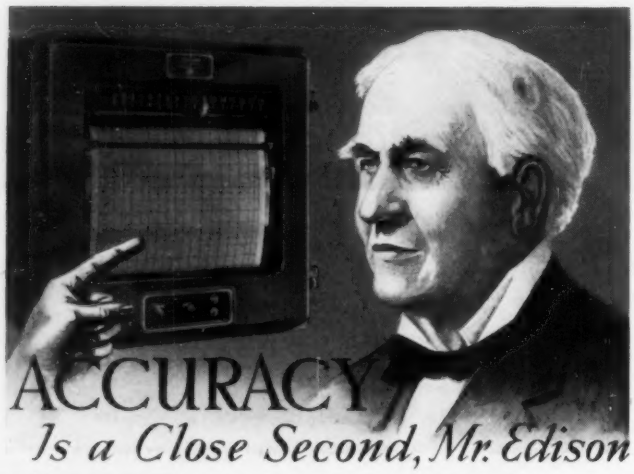
former will stand continuous direct application of the 115 volts a.c.

The transformer core (see illustration) is so designed that a short circuit in the applied secondary will not burn out the primary. It has no secondary terminals for heavy current to damage and no switching or plugging devices to complicate construction or maintenance. Cost of construction is low. Standard transformer laminations are stacked, heavily taped together, dipped and baked. This is to produce a vibration-free stack. The primary is then laced in and also heavily taped as this coil acts as the support or base of the unit. It is again dipped and baked. Coil consists of 230 turns of No. 14 cotton enamel wire.

This unit has also been built in a 3-kw. size using 1 turn per volt with 115 turns No. 10 wire for a primary. Core dimensions were such that 10½ square inches or twice that of the 1-kw. unit, was obtained.

The uses the above transformers have been put to so far are as follows: Relay testing, both voltage and current, soldering, spot welding, hard soldering (carbon contact type), pipe thawing, low-voltage appliance testing such as bells, buzzers, horns, toy motors; and as emergency replacement unit for burned-out low-voltage control transformers.



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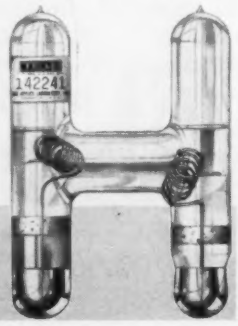

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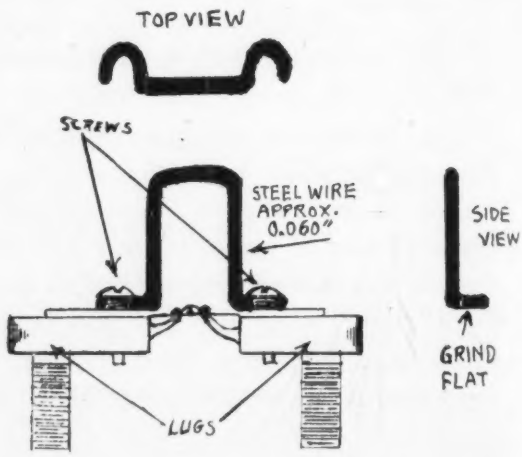
Protecting Thermocouple of R-f. Ammeter During Overhaul

By RANSOM H. BURT
Jacksonville, Florida

HERE is a simple little gadget to be used in removing, replacing or repairing the thermocouple unit in Weston radio-frequency ammeters. A piece of steel wire (approx. 0.06" in diameter and about 3" long) is bent at the middle in the



shape of a "U" and each end is bent into a smaller "U" to fit under the heads of the screws holding the insulating material and corrugated strips. Then it is fitted by bending carefully at right angles so that the two U-shaped feet are as level as possible in relation to the brass lugs on which the wire gadget is to fit. The gadget is then held on the flat side of a grinding wheel and its feet levelled. This will allow the screws to be tightened without caus-

ing the thermocouple unit to be twisted upon removal.

When the thermocouple unit is to be removed, the screws are turned to the left a few turns; the gadget is slipped underneath and the screws tightened. Then, the nuts are taken off the lugs on the back of the instrument case and the thermocouple unit is lifted out. Now, with the gadget on it (see illustration) the unit can be cleaned or inspected without danger of damage to the delicate wires that compose the thermocouple.

Pivoting

By JOHN E. MORRISON
Flanagan, Illinois

IT is important for instrument mechanics who have knowledge of small lathe work, such as can be accomplished on a jeweler's lathe, to understand pivoting because new parts for instruments are difficult to obtain and because pivots are broken or rendered unfit for use in many ways: Small instruments are often dropped or severely jarred, causing pivots to bend or break; also, if pivots are not properly oiled and become dry, they soon wear and the only remedy is a new pivot. Many workmen resort to almost every conceivable method to avoid the task of pivoting. The natural conclusion would be that pivoting is very difficult and that few instrument mechanics could perform it in a satisfactory manner. Pivoting is not easy and will require skill if the work is done properly. When the repair has been completed, it should be as the original and not show where it was repaired.

A good many pinions are too hard to be drilled without drawing temper. Copper should be used as it is the best conductor of heat we have at hand. A good method is to have several pieces of copper wire, with various sizes of holes drilled in them which will closely fit part of pinion or staff to be drawn. Heat wire quickly and remove copper wire when steel is drawn proper amount.

One important thing is to have our work absolutely true whether we use chucks or cement. When a pinion or staff pivot runs true in lathe, light reflected from surface will appear perfectly still. Should it not be true, the light reflected will waver. This is one of the most delicate ways of testing. After you have trued your work in lathe you are ready to drill. Select the proper drill and see that cutting edge is sharp. The drill can be held in a pin vise and drill should project out of pin vise but little more than depth of hole to be drilled. By this method you will find there is less danger of breaking drill. After hole has been drilled, select proper steel wire for making pivot. Some workers have used a high-grade needle, cutting them to fit. Pivot or plug to be fitted in hole should be tapered so that it will bind slightly when inserted. Be sure that plug reaches bottom of hole. After pivot has been set and trued you are ready to cut to size. Now grind with oilstone powder and oil; next grind with crocus and oil. After cleaning, polish with diamantine in oil and use just enough oil to make rather thick paste. As I have stated before, remember that when pivoting work has been completed it should appear as new.

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A "Refresher" on Principles of Mechanics for Instrument Men

By S. R. WILLIAMS
Professor of Physics, Amherst College, Amherst, Mass.

The objective of Physics is to describe as accurately and clearly as possible the physical processes which go on in the universe about us. Therefore, Mechanics attempts an accurate and clear-cut description of the conditions of rest or motion of the objects about us, because Mechanics is that Science which treats of the action of forces on bodies. All

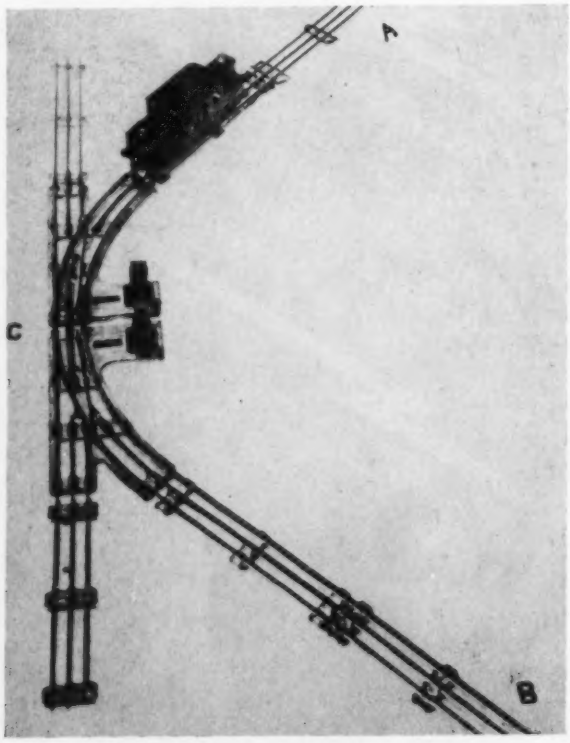

Fig. 1. The electric locomotive as it progresses from *A* to *B* via *C* has both a motion of translation and of rotation.

types of motion may be broken down into two kinds, translatory and rotatory. Thus a body passing over a curved path is proceeding from one point to another as in translatory motion and at the same time it is being turned. A locomotive rounding a curve is a good illustration. The locomotive proceeds from *A* to *B* via *C* (Fig. 1) and has a speed of translation along the track as it progresses. It is also turned (rotated) through about 90° in the figure as it travels from *A* to *B* via *C*.

So many of our measuring instruments depend upon one kind or another of the various types of motion that we need a clear understanding of motion in its various forms. This is particularly true for recording and control instruments. Thus in our time-keeping devices, an accurate time-piece demands a motion which is uniformly constant. In the case of the electricity meters which measure the electrical energy we use in our houses, the disk rotates between the poles of the magnet at a rate proportional to the watts of power being consumed. A thorough understanding of the types of motion available is quite essential in devising new gadgets for measurement and control. The adaptability of a measuring instrument for a definite purpose depends upon the type of motion found in its moving parts. Cams, eccentrics, etc., are illustrations of this point.

Demonstration of Uniform Speed or Velocity

If a body has a uniform speed, that is, a uniform rate of change of position, we may define it by the equation

$$v = \frac{d}{t},$$

where d is the distance passed over in the time t, whether in a straight or a curved line and v is the *average* speed or velocity.

Linear uniform speed or velocity may be demonstrated as in Fig. 2 by having an electric motor of uniform speed of rotation wind up a rope on a drum which draws the cart *c* along the top of the table. If the speed is regulated by means of a friction drive, the pointer *p* on the cart may be made to pass each succeeding post on the board at the exact tick of the metronome. A synchronous motor like those used in a large electric clock makes a good constant speed motor. They are so constant we use them for keeping time. See Fig. 11 (Time) in the previous article (December). Variability in speed of the winding drum *D* is produced by a friction gearing and when set for a fixed ratio of the two friction surfaces, the drum then goes on with constant speed.

Demonstration of Uniformly Accelerated Linear Speed or Velocity

Often the speed or velocity varies. Then we have accelerated speed or velocity. If the rate of change of speed or velocity is uniform we have uniformly accelerated speed or velocity, $a = v/t$.

Allow the cart shown in Fig. 2 to roll down an inclined plane as in Fig. 3. Arrange the slope of the inclined plane and the rate of the metronome so that at each tick of the metronome the pointer *p* on the car will be passing one of the little posts along the inclined board. No longer does the body move over equal spaces in equal periods of time, but

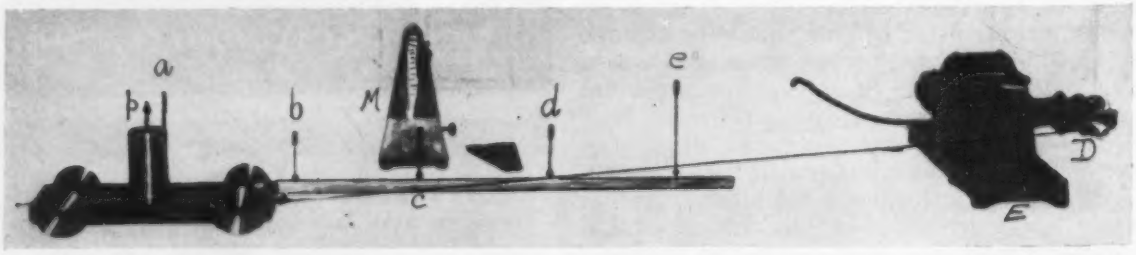

Fig. 2. Uniform Speed or Velocity. The winding drum *D* is driven by a constant-speed motor *E*. As the cord winds up on the drum *D*, the cart moves forward equal spaces with each tick of the metronome *M*.

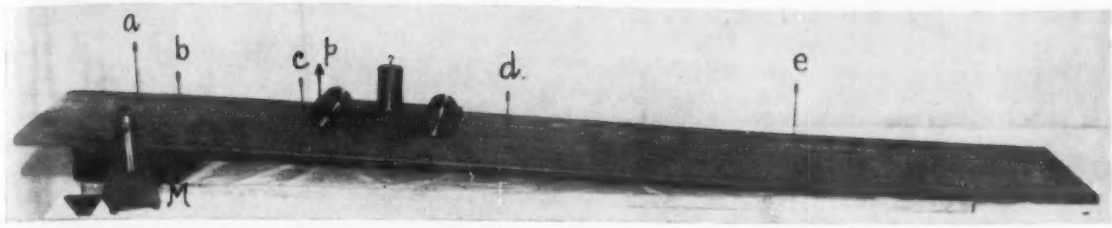

Fig. 3. Uniformly Accelerated Motion. The cart, loaded with a 2-kilogram mass, rolls down the inclined plane with ever increasing speed. At each tick of the metronome the pointer *p* on the car passes one of the pylons *a*, *b*, *c*, *d* and *e*.

the space passed over each time is increasing at a rate proportional to the square of the time, i.e., $d = \frac{1}{2}at^2$.

We may have a speed or velocity which is diminishing. Such motion we speak of as a decelerating speed or velocity. If the cart is shot up the inclined plane with a given initial speed its speed up will be a decreasing one and it will finally come to rest and then begin to roll down again.

Linear Motion Which Has Variable Acceleration

Finally we have a motion in which even the acceleration is varying. This is often the case in driving an auto in traffic.

Demonstration of Uniform and Uniformly Accelerated Angular Speeds or Velocities

Just as we demonstrated uniform linear speeds or velocities and uniformly accelerated linear speeds and velocities, so we may demonstrate uniform and uniformly accelerated

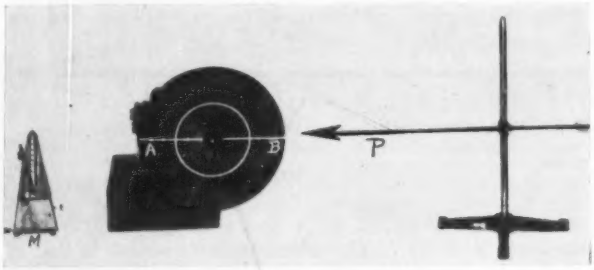

Fig. 4. Uniform Angular Speed. The disk driven by an electric motor of uniform speed can be made, by means of a variable-speed friction-drive clutch, to have a constant speed such that the point *A* or *B* passes the pointer every tick of the metronome *M*.

angular speed and velocities. These are days of motors and internal combustion engines. Rotatory motion is even more important than translatory motion if we consider our prime movers, to say nothing of our recording instruments.

Attach to the winding drum in Fig. 2 a divided circle as shown in Fig. 4, and show that equal angles are swept out in equal intervals of time when the motor runs with uniform speed. If the disk is started from rest then it goes from a velocity at the start which is zero up to some finite speed which then becomes constant on the rotator used. While the angular speed is changing we have an illustration of an accelerated angular speed, but after the fixed speed is attained then the end of the white line on the disk

So much interest was shown in Dr. Williams' article on Metrology (Dec. '42) that he is preparing a serial on the other physics subjects which instrument men should know—all articles to consist of "demonstrations on paper," whereby the reader "witnesses" demonstrations and almost "makes experiments." This is the second article. The remaining ones (we all hope) will appear more frequently than every four months. —M. F. Behar, *Editor*

arrives at the pointer *p* (Fig. 4) at every tick of the metronome. The speed of the disk and the period of the metronome can both be adjusted so that the ends of the line, *A-B*, arrive at the pointer *p* synchronously with the beats of the metronome. The angular speed and the angular acceleration may be represented by the following equations respectively:

$$\omega \text{ (omega)} = \frac{\theta}{t} = \frac{\text{angle}}{\text{time}} = \text{angular speed, and}$$

$$\alpha \text{ (alpha)} = \frac{\omega}{t} = \frac{\text{angular velocity}}{\text{time}} = \text{angular acceleration}$$

Demonstration of a Combined Linear and Angular Acceleration of Motion

Often we have a combination of linear and angular accelerations in some of our instruments. This is true in ball-bearing instruments and, as we shall see later on, under the subject of energy, such accelerations require forces and torques to produce them and therefore a problem for the engineer in designing instruments of measure and control.

On the inclined plane used in Fig. 3, allow a wooden disk to roll down the plane as in Fig. 5. The period of the metronome and the inclination of the plane may both be adjusted so that the center of the disk will just be passing the little pylons, *a*, *b*, *c*, *d*, etc., set up on the plane at each tick of the metronome. It will be seen that each succeeding unit of time measured off by the metronome carries the disk a greater distance than the preceding one. Simultaneously the white line across the disk marks off larger and larger units of angular speed for each succeeding unit of time.

Angular Motion Which Has Variable Acceleration

This is the type of motion found in the fly-wheel of an auto engine when driving in traffic.

Fig. 5. The rolling disk will illustrate both linear and angular accelerated motion.

Circular Measure—Demonstration of the Radian

In Physics it is customary to express angles in radians instead of degrees. There are times when degrees become handier, however, as for instance in reading a transit instrument or the divided circle on a spectrometer. The unit of circular measure, the radian, must be thoroughly understood if we are to measure angles in absolute units.

In Fig. 6 is a disk whose diameter is 30 centimeters. If on the periphery of this circle one lays off a length $A\text{-}B = 15$ centimeters, just equal to the radius of the disk, say OA,

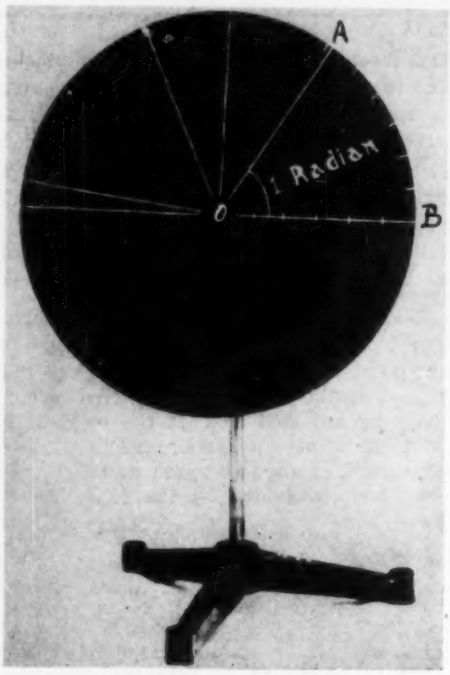

Fig. 6. The arc *A-B* has a length just equal to the radius *OA* or *OB*. The angle which this arc subtends is called a radian, which is the unit of circular measure and equals 57°.2958 2π radians $= 360°$.

then the angle AOB subtended by $A\text{-}B$ is called a radian. There are 2π radians subtended by the entire circumference of the disk, therefore,

$$2\pi \text{ radians} = 360°$$
$$\text{or } 1 \text{ radian} = 57°.2958$$

Any other angle in degrees may be expressed in terms of radians by means of this ratio. Angular displacements, angular velocities and angular accelerations must be expressed in terms of radians if we are to express our units of measurement in fundamental units.

If in Fig. 6 a line like OA has a mass at A which is moving around the periphery of the disk, we call the line joining the center O with the mass at A, the radius vector. The line joining the center of the sun with the center of the earth is called a radius vector.

Let the mass M at A move around the circle with a uniform speed of v centimeters or inches per second. Simultaneously the radius vector always moves with uniform angular speed ω which is related to the linear speed v by the following relation

$2\pi r = C$, the circumference of a circle

$\frac{C}{2\pi} = r$, the radius of the circle, that is

$$\frac{\text{arc}}{\text{angle}} = \text{radius}$$

Dividing both C and 2π by the period T or one revolution gives

$$\frac{C/T}{2\pi/T} = \frac{v}{\omega} = r = \frac{\text{linear velocity}}{\text{angular velocity}}, \text{ or } v = \omega r.$$

If we divide again by the time T, both v and ω, we get the relation that the linear acceleration divided by the angular acceleration is

$$\frac{a}{\alpha} = r = \frac{\text{linear acceleration}}{\text{angular acceleration}},$$
$$\text{or } a = \alpha r$$

These are relations which come up often and must be mastered at the outset.

Demonstration in the Use of Vector Quantities

In physical calculations there are two kinds of quantities, vector and scalar. Scalar quantities involve magnitude only. Examples: liters of water, cubic centimeters of mercury. Vector quantities are those possessing both magnitude and direction. Examples: Velocity, force, momentum. We can

Fig. 7. A vector quantity may be represented by a line whose length is proportional to the magnitude of the vector and whose direction is that of the vector.

represent such quantities by a line usually in the form of an arrow as in Fig. 7. The direction of the line is that of the vector it represents and its length is proportional to the magnitude of the quantity. Thus quantities like force, velocity, acceleration and momentum are vector quantities and we are interested in their direction as well as in their magnitude. It is customary in Physics to call undirected change of position *speed;* when directed we call it a *velocity.*

Demonstration of Three Forces in Equilibrium by Vector Representation

In Fig. 8, two spring balances, S and S', are hung on hooks at the top of the blackboard. At a point about a quarter of the distance along the string stretched between them are hung two 2-kilogram masses. The balance S reads 5.2 kilograms and S' reads 4.5 kilograms. If, along the two

Continued on page 156

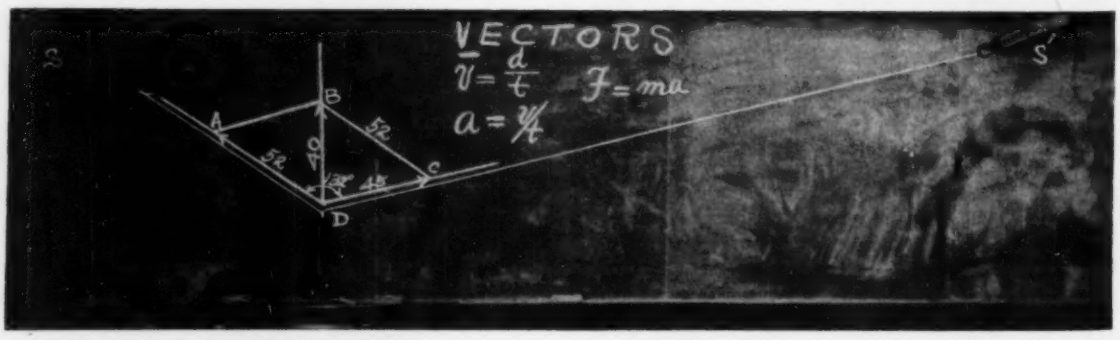

Fig. 8. Three concurrent forces are in equilibrium at the point *D*. These are represented in magnitude and direction by the sires and diagonal of the parallelogram, *ABCD*.

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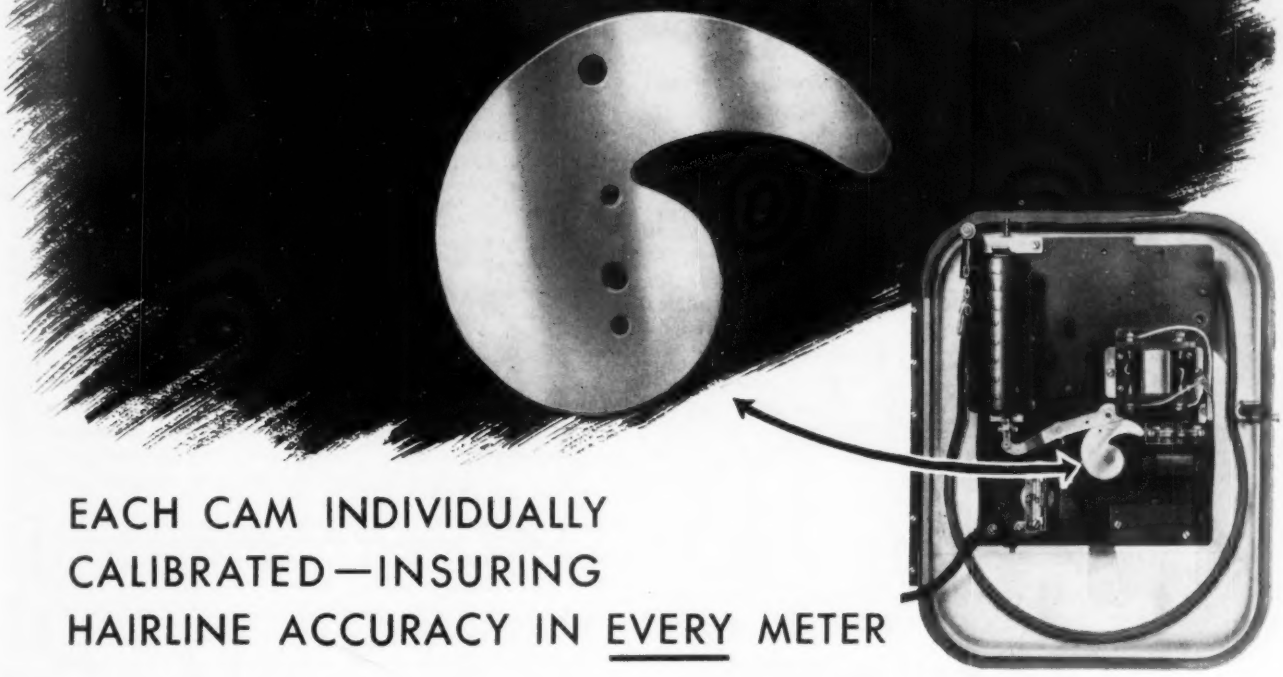

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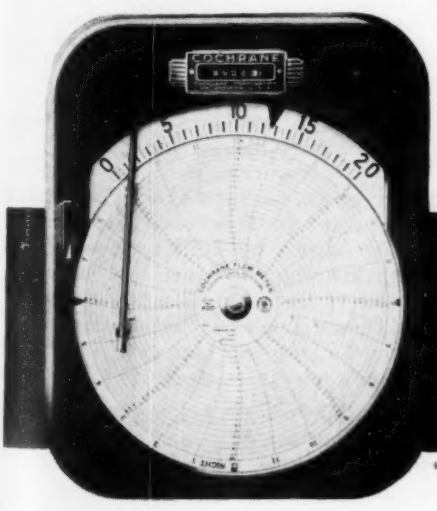

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Ordnance Production Gaging

By CAPTAIN RUSH A. BOWMAN

In charge of Pittsburgh Gage Laboratory, Ordnance Department, U. S. Army

CHAPTER VI

Taper and Angle Determinations

The gaging of tapers involves some of the unique problems or difficulties in the field of inspection. The size and shape of conical sections or tapers are determined by specifying:

(*a*) Two diameters with a length between—each with tolerance.

(*b*) A diameter, a taper and a length—each with tolerance.

(*c*) Two diameters and a taper—each with tolerance. (Note: This type of specification is seldom used.)

(*d*) A diameter with tolerance, axial position as a reference (no tolerance), and the taper a reference (no tolerance) allowing cone or taper to run into other cylindrical

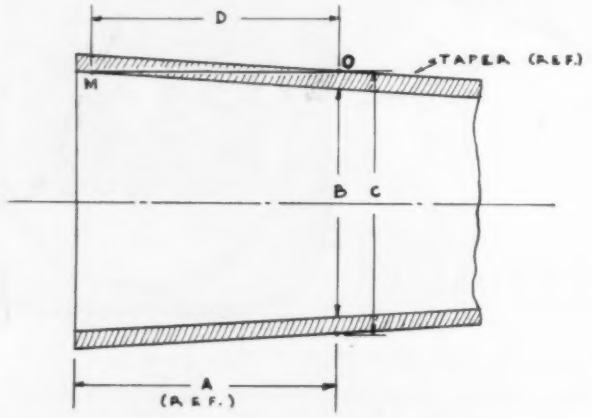


Fig. 1. Method of specifying a tapered part is shown. At a distance *A* from the face of the pin, the diameter must be between *B* and *C*. No tolerance is shown on either *A* or the taper. Any surface lying entirely within the shaded area is therefore within tolerance.

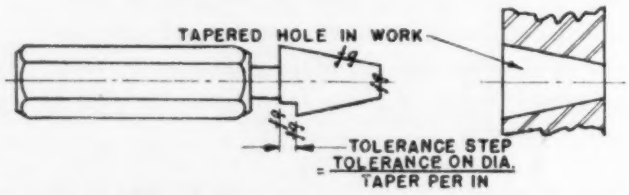


Fig. 2. A taper plug gage and the component which it inspects. Note that the step is a quotient, and therefore, a magnification of the tolerance on the diameter as long as the angle is less than 45°. Note further than the smaller the taper, the greater is the magnification.

or conic surfaces or planes. (Note: At an untoleranced position, such as *O* in Fig. 1, if limits on diameter are described and surfaces are passed through these limits, they will describe the limiting surfaces which may exist. Then, any smooth surface whose points fall between these limits is acceptable.)

The difficulty arises from the fact that, in general, one gage only is used in taper determinations. And, theoretically, that single gage should measure both limits of each of the elements involved in the specification of that taper. Actually, this is an impossibility in each of the first three cases above. If the gage is a taper plug, it really gages more in accordance with (*d*). Quite logically, this is the method which is now being adopted in specification of tapers.

The taper plug or ring does not gage even according to the specification of (*d*). Note again Fig. 1. If *B* is the minimum diameter of the cross-section a *O*, and *C* is the maximum, then in order to gage strictly in accordance with the specification, it would be necessary that the distance *A* be fixed and that the taper ring contract normal to the axis like an iris diaphragm until it contacted the outside of the taper pin shown. It would then be necessary to determine whether the part was in tolerance by the amount of contraction at the position *O*. All this, of course, is impracticable. In actuality, the taper ring slips over the pin and a movement *D* is possible within the limits of tolerance of the part since the diameter at *O* is the same as the diameter at *M*. The gage then is designed with the correct taper and with the maximum diameter *C* at the critical point *O*. It may go on the tapered part a distance *D* beyond the reference point *O*. This travel, representing the tolerance, is usually shown by allowing the tapered part to extend through the ring gage with two flush surfaces ground on the end of the ring indicating the maximum and minimum distance axially at which diameter *C* may exist. This step on the ring will obviously correspond to *D* less the gage maker's tolerances. See Fig. 3.

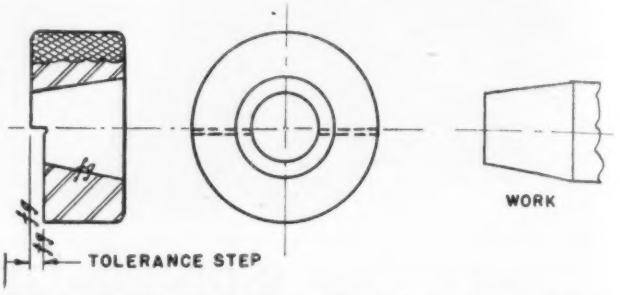


Fig. 3. A taper ring gage and the component which it inspects. Note step to show tolerance. The same rule with respect to magnification applies as in the plug.

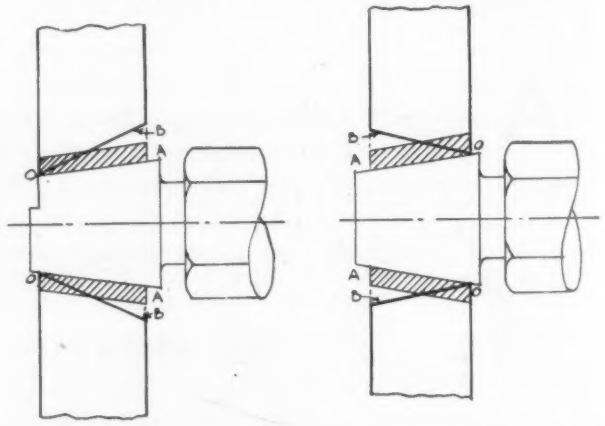


Fig. 4. Two cases where the gage will show part to be within tolerance while actually it is not. Shaded section *A* represents desired tolerance on part. The line *B* is the actual surface of the part. The gage contacts the part in each case at *O* which is within tolerance, passing the part while actually it should not be accepted.

Difficulties arise when tapers begin to "run out" so that they will pass at one end of the gage and yet be undersize at the other end (or oversize in the case of a taper hole). See Fig. 4.

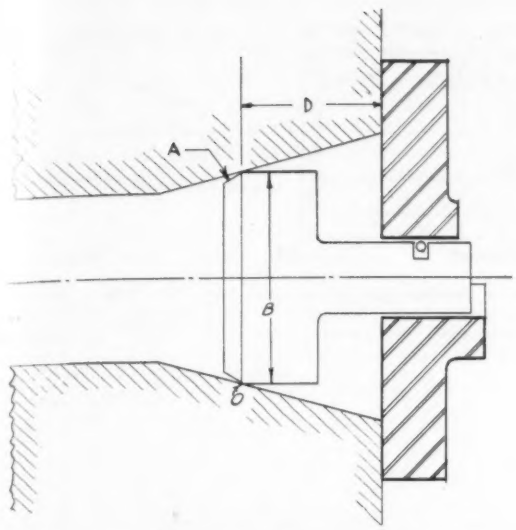


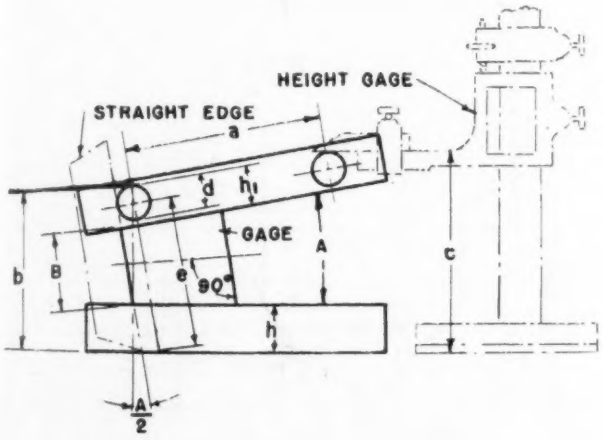
Fig. 5. A flush pin gage being used to inspect a countersink. This gage is determining the position of a diameter *B* from the face of the part. In this case, it is at *O*, a distance *D* from that face. Note relief of the angle at *A*.

It is apparent also that if this difficulty is experienced in gaging, it may likewise be expected to occur in functioning of the parts in the assembly. As a consequence, one diameter on a taper will be taken as the critical point. This diameter will normally be recognizable by the method of dimensioning on the component drawing.

For this reason, the practice has grown up of gaging the axial position of a particular diameter along the taper.

The gage design often takes the form of a flush pin gage. See Fig. 5. In most cases, one diameter measured this way is satisfactory with a spot check of the taper. Such a spot check is made with an optical comparator, or by "blueing in" a master taper, or with a bevel protractor.

Where, in addition to a diameter, the taper is also critical, a diameter may be checked at several different points with the above method, one flush pin being used to measure the critical diameter, the other flush pins to determine that the taper is not "running out."



FORMULA

$$\sin A = \frac{c-b}{a}$$

$$\theta = \frac{b-\frac{d}{2}}{\cos\frac{A}{2}}$$

$$B = \theta - \left(\frac{h_1-\frac{d}{2}}{\cos\frac{A}{2}} + \frac{h}{\cos\frac{A}{2}} + d\tan\frac{A}{2}\right) = \text{DIA. SMALL END OF GAGE}$$

Fig. 6. Measuring a taper plug with a sine bar.

This unique serial is based on the remarkably successful course of lectures by Captain Bowman (then Lieutenant) to us Reserve Officers, in which he combined the fruits of his civilian experience as Gage Supervisor and of his Ordnance training.

—M. F. Behar, *Editor*

CHAPTERS PREVIOUSLY PUBLISHED. I. Interchangeability—Sept. '41 and May '42; II. Inside Dimension Gaging—July '42; III. Outside Dimension Gaging—Aug. '42; IV. Offset Dimension Gaging—Sept. '42; V. Position and Alignment Gaging—Oct. '42; VII. Profile Determinations—Dec. '42; VIII. Thread Gaging—Feb. '43; VI. Taper and Angle Determinations—Mar. '43.

Still another method is sometimes used in which the critical diameter is checked and, in addition, the complete profile is also checked by "blueing in" a plug or ring with the part. This latter system is used in checking the chamber and forcing cone of a gun where the interior is extremely critical not only from the standpoint of size, but also form, surface, etc.

This does not mean that the taper plug and taper ring are no longer used, but their use is limited to cases where conditions such as those in Fig. 4 will not be of great consequence.

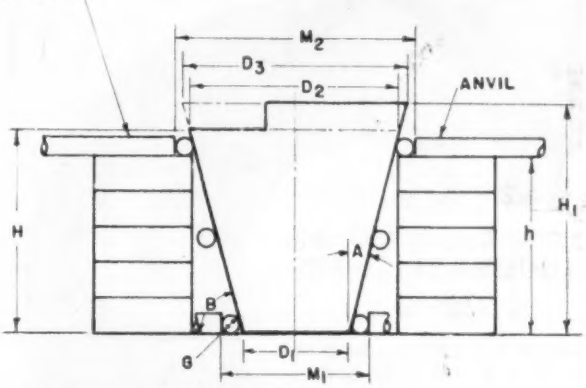
No wear is allowed on the taper plug because as a taper plug wears, the position of a given diameter will merely move toward the larger end in a plane normal to the axis. In general, the angle itself on the plug will tend to become more nearly the theoretical requirement of that taper.

Inspection

Taper Plug and Ring

A number of methods are used in the inspection of a taper plug. Two such methods are herein shown, see Figs. 6 and 7. While either method represents complete inspec-

SPINDLE OF MEASURING MACH. SUPER MICROMETER OR MICROMETER CALIPER



G = DIA. OF MEASURING ROLLS
h = HEIGHT OF GAGE BLOCKS USED
H & H1 = LENGTH OF TAPER PLUG MIN. & MAX. STEPS
C = TAPER PER INCH = $\frac{M_2-M_1}{h}$

FORMULAS

$$\text{TAN } A = \frac{\frac{M_2-M_1}{2}}{h}$$

$$B = 90°-A$$

$$D_1 = M_1 - \left(G \text{ COT. } \frac{B}{2} + G\right)$$

$$D_2 = D_1 + HC \text{ OR } D_1 + 2(H \text{ TAN. } A)$$

$$D_3 = D_1 + H_1 C$$

EXAMPLE:

LET G=.2000 h=1.000 H=1.50 H1=1.55 M1=1.93834 M2=2.291

$$\text{TAN. } A = \frac{\frac{2.291-1.93834}{2}}{1.0} = .17633 = \text{TAN. } 10°$$

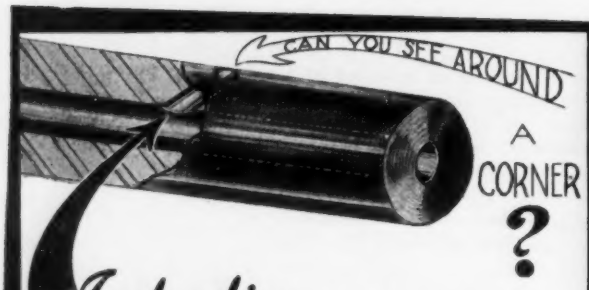
$B = 90° - 10° = 80°$

$D_1 = 1.93834 - (.2 \text{ COT. } 40° + G) = 1.93834 - .43834 = 1.500$

$D_2 = 1.500 + 3. \text{ TAN. } 10° = 2.029$

$D_3 = 1.500 + 3.1 \text{ TAN. } 10° = 2.0466$

Fig. 7. Roll method of measuring taper plug gages.



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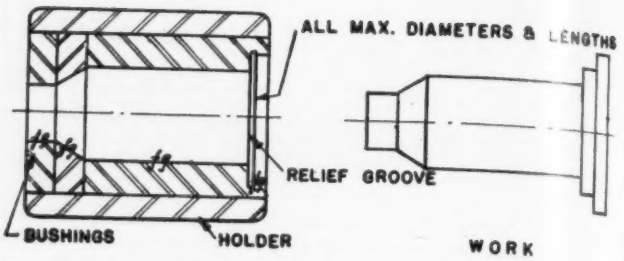
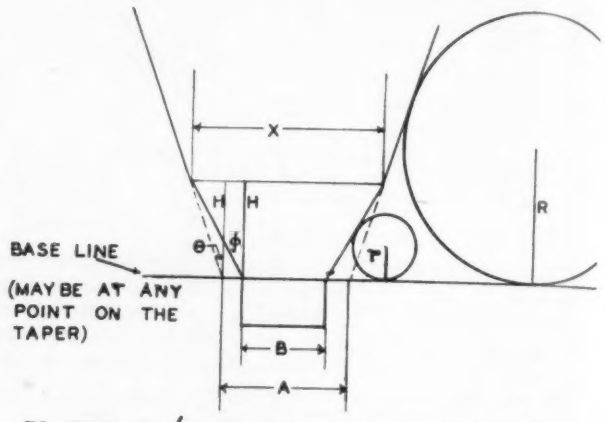


Fig. 8. A chamber gage for cartridge case. This gage is particularly common since it is used in inspection of every cartridge. This gage is checked by "blueing-in" with master similar to the "Work" or component being produced.

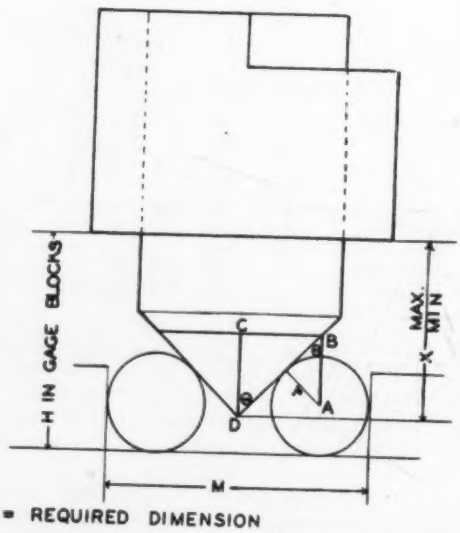


TO FIND X (TAPER PREVIOUSLY DETERMINED)

$$X = A + 2H \tan\theta$$
$$X = B + 2H \tan\phi$$
$$A + 2H \tan\theta = B + 2H \tan\phi$$
$$H = \frac{A - B}{2(\tan\phi - \tan\theta)}$$

MAY BE USED TO CHECK CHAMBER GAGES, CARTRIDGE CASE CHECKS, METALLIC BELT LINK 30 CAL. M.G.

Fig. 9



X = REQUIRED DIMENSION

M = PREVIOUSLY SET DISTANCE, PARALLELS OR SLOT

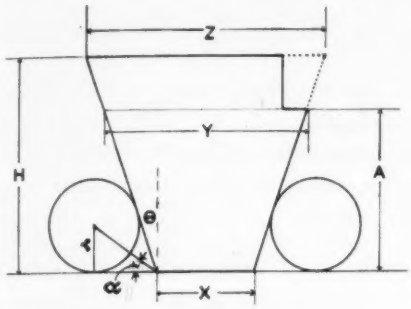
$X = H - (AB + r - CD)$

$AB = r \csc\theta$ $\qquad CD = \frac{M - 2r}{2} \cot\theta$

$$X = H - r(\csc\theta + 1) + \cot\theta\left(\frac{M - 2r}{2}\right)$$

Fig. 10

tion within itself, if both sine bar and rolls are available, it usually is well to make use of the sine bar in connection with the inspection of the angle, and the gage blocks, rolls, micrometer, or super micrometer for the determination of the position of the reference diameter. In Fig. 6 it will be noted that it is necessary to hold a straight edge to the end of the plug and align this with the button on the sine bar. This procedure is somewhat difficult, hence a common source



X, Y, Z = REQUIRED DIMENSIONS

M = MEASUREMENT OVER ROLLS OF r RADIUS

$\alpha = \frac{90° - \theta}{2}$

$X = M - 2r(1 + \cot \alpha)$

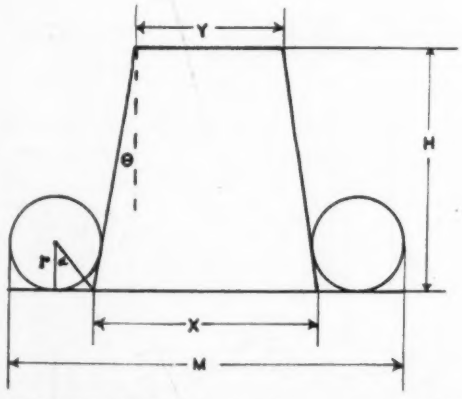
$Y = X + 2A \tan \theta$

$Z = X + 2H \tan \theta$

Fig. 11

of inaccuracies; and absolute alignment is necessary in order that this method of inspection be accurate. The determination of angle only is necessary. The position of the plug with respect to buttons on the sine bar is of no consequence. The angle is determined merely by the difference in height of the buttons. The complete formula for this method is given, however.

The method shown in Fig. 7 is simpler because the angle is already known in that only one set of readings is necessary. There is a definite possibility that when the three po-



M = MEASUREMENT OVER ROLLS OF r RADIUS.

X, Y = REQUIRED DIMENSIONS. $\alpha = \frac{90° - \theta}{2}$

$X = M - 2r(1 + \tan \alpha)$ $Y = X - 2H \tan \theta$

Fig. 12

sitions are measured and the angle determined from these measurements, such angle determination may be inaccurate by reason of possible slight irregularities in the surface.

One idea is frequently overlooked in the inspection of extremely slow tapers. Slow tapers are often hard to measure, especially when they intersect another taper or a cylindrical surface. It often is necessary to determine diameters at the intersection of such surfaces which are not readily measurable as in the case of chamber gages (see

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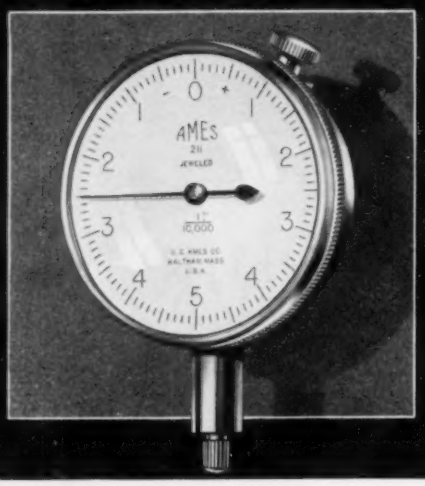

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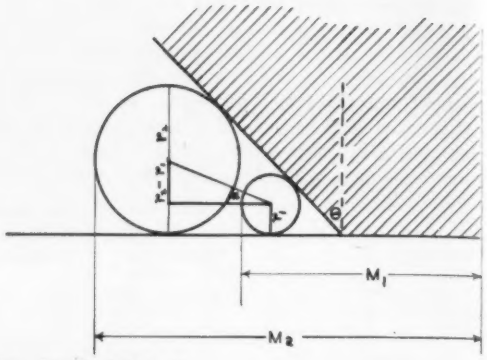
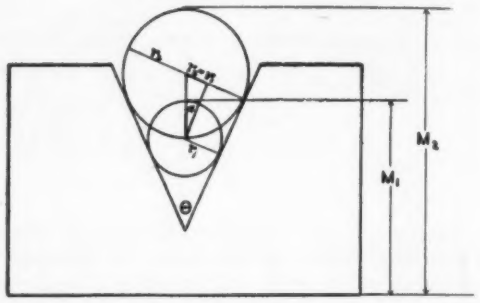


GIVEN DIMENSION M_1
OVER PRESCRIBED ROLL OF RADIUS r_1
TO FIND M_2 - MEASUREMENT OVER SUBSTITUTE ROLL OF RADIUS r_2

$$\alpha = \frac{90° - \theta}{2} \qquad M_2 = M_1 + r_2 - r_1 + \cot\alpha\,(r_2 - r_1)$$

Fig. 13



TO FIND θ BY MEASURING OVER TWO ROLLS OF DIFFERENT DIAMETER

r_1 = RADIUS OF SMALLER ROLL

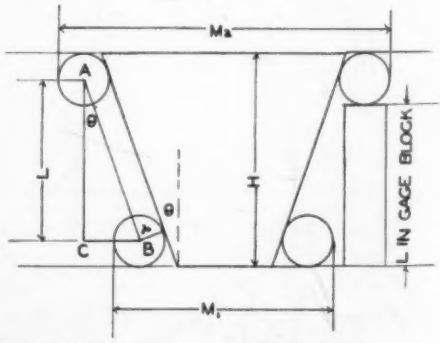
r_2 = RADIUS OF LARGER ROLL

M_1 = MEASUREMENT OVER SMALLER ROLL

M_2 = MEASUREMENT OVER LARGER ROLL

$$\sin\alpha = \frac{r_2 - r_1}{M_2 - M_1 - r_2 + r_1} \qquad \theta = 2\alpha$$

Fig. 14



TO DETERMINE ANGLE θ OF TAPER PLUG

M_1 & M_2 = MEASUREMENTS OVER ROLLS OF r RADIUS

L = HEIGHT IN GAGE BLOCKS

$$AC = L \qquad CB = \frac{M_2 - M_1}{2}$$

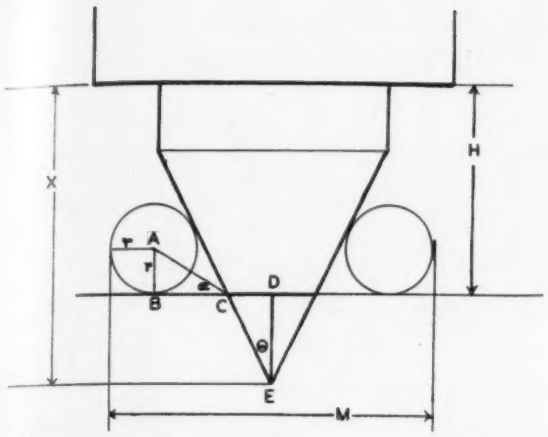
$$\therefore \tan\theta = \frac{CB}{AC} \quad \text{OR} \quad \tan\theta = \frac{M_2 - M_1}{2L}$$

IF GAGE IS INVERTED TO SECURE M_2, HEIGHT OF GAGE, H, MAY BE USED TO FIND ANGLE.

$$\tan\theta = \frac{M_2 - M_1}{2(H - 2r)}$$

DIAMETRAL TAPER PER IN. = 2 TAN θ

Fig. 15



$$\alpha = \frac{90° - \theta}{2} \qquad X = H + DE \qquad DE = CD \cot \theta$$

$$CD = \frac{M - 2r - 2BC}{2} \qquad BC = AB \cot \alpha \qquad AB = r$$

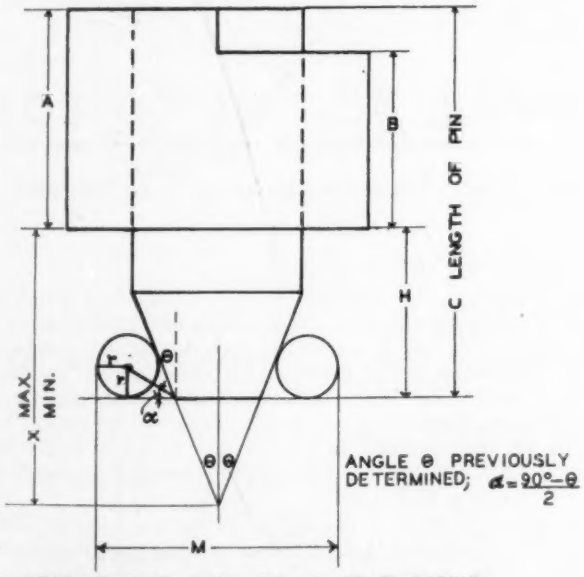
$$\therefore CD = \frac{M - 2r - 2r \cot \alpha}{2} = \frac{M - 2r(1 + \cot \alpha)}{2}$$

$$\text{AND } DE = \frac{\cot \theta [M - 2r(1 + \cot \alpha)]}{2}$$

$$\text{THUS } X = H + \left\{\frac{\cot \theta}{2}\left[M - 2r(1 + \cot \alpha)\right]\right\}$$

Fig. 16

Fig. 8) and the corresponding cartridge case gages. *If the taper is 0.050" per inch of length, the axial travel for a change of 0.0001" in diameter is 0.002"; if the taper is 0.005", the axial travel for a change of 0.0001" in diameter is 0.020", etc.* It may be seen that in some cases the crudest method of length measurement may sometimes be employed



M = MEASUREMENT OVER ROLLS OF r" RADIUS

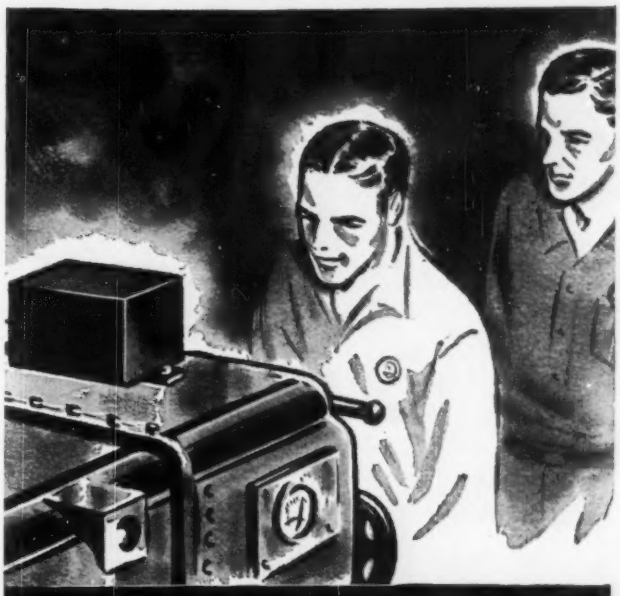
X = REQUIRED DIMENSION

H = HEIGHT IN GAGE BLOCKS WHEN PIN IS FLUSH

$$X = H + \left\{\frac{\cot \theta}{2}\left[M - 2r(1 + \cot \alpha)\right]\right\} \quad \text{OR}$$

$$X = C + \left\{\frac{\cot \theta}{2}\left[M - 2r(1 + \cot \alpha)\right]\right\} - A \text{ (OR B)}$$

Fig. 17



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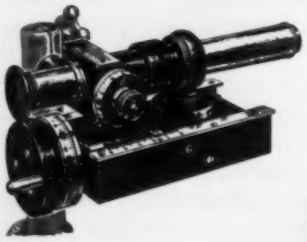
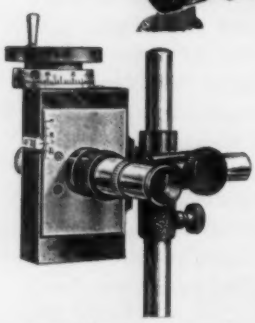
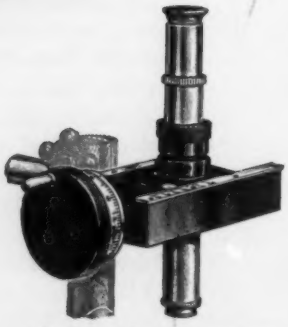


micrometer focusing





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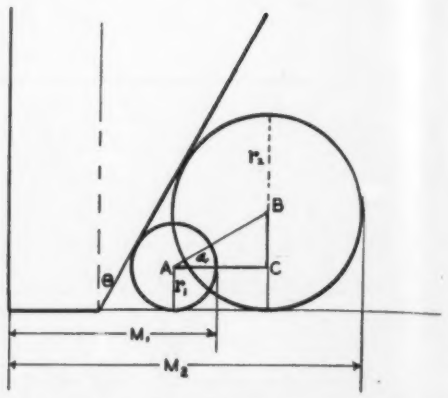

TO DETERMINE ANGLE θ BY MEASURING OVER TWO ROLLS OF DIFFERENT DIAMETER

M_1 = MEASUREMENT OVER SMALLER ROLL

M_2 = MEASUREMENT OVER LARGER ROLL

r_1 = RADIUS OF SMALLER ROLL

r_2 = RADIUS OF LARGER ROLL

$\theta = 90° - 2\alpha$ $\quad \tan\alpha = \frac{CB}{AC}$ $\quad CB = r_2 - r_1$

$AC = (M_2 - r_2) - (M_1 - r_1)$ $\quad \tan\alpha = \frac{r_2 - r_1}{M_2 - M_1 - r_2 + r_1}$

Fig. 18

to determine the diameter of a taper at a given point to close limits of measurement if the actual taper is known.

Taper rings are invariably mastered with a taper plug. The plug is "blued-in" to determine that the surface contact is comparatively regular. The inspection of this master is, of course, the same as the inspection of an ordinary taper plug gage.

A number of specific gage inspection problems, and their solutions, are shown in the drawings of actual inspection setups, Figs. 9 to 18.

LETTER TO THE EDITOR

Air Flow Measurements to Engines and Carburetors

To the Editor of *Instruments:*

In connection with Mr. J. P. Green's interesting article on the above subject in the February issue of *Instruments*, the writer believes that it would be advisable to call attention to a possible source of considerable error in the measurement of air or gas flow to or from reciprocating engines or compressors. Such an error may result from pulsations set up in the line through which the flow is being measured. Such pulsations seriously affect the accuracy of any manometer indications of flow rate.

An example of this was called to the writer's attention some time ago, when difficulty was experienced in obtaining an accurate air measurement of the flow to the carburetor of a six-cylinder automobile engine operating at about 3,000 r.p.m. In order to iron out these pulsations, which were of course, entirely invisible and undetectable on the manometer, it was found necessary to install two (2) capacity chambers of approximately 50-gallon capacity each, between the measuring orifice and the carburetor intake. A single capacity chamber was first tried, and while this considerably reduced the error, the two (2) chambers in series were necessary to eliminate it completely.

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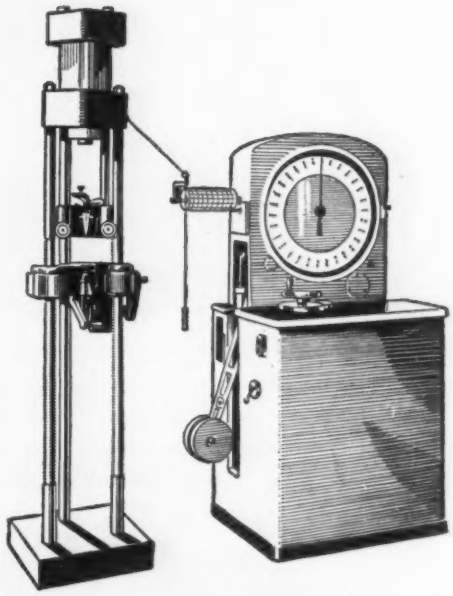

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"AFTER THE WAR, my wife will probably have *her* say when we shop for a family plane. She can have her choice of color, but I'll choose the instruments—*precision* instruments that can take it when the going gets tough, and still tell the *truth.* When I fly, I want to know where I'm going. With me, it's not *how fast* . . . it's *how sure!*"

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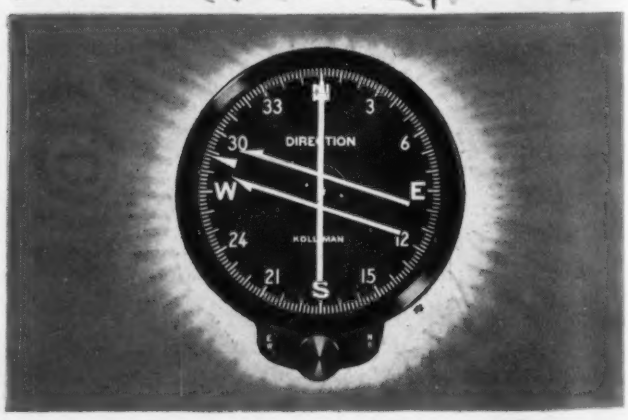

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Navigation Automatic-piloting Power plant Automatic-landing Aerological
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Vol. II, No. 3 SPECIAL ISSUE March 1943

WELCOME TO THE AIRCRAFT INSTRUMENT GUILD!

THIS extraordinary issue of the Aviation Instruments Department is the fulfilment of a promise—and it also is in itself a promise of future achievements which are expected to benefit both aviation and instrumentation.

In the first issue of this Department (June 1942) it was announced that Guest Editors, all drawn from the field of education, would be in charge of subsequent issues. Our very first Guest Editor, who contributed the material for the July 1942 Aviation Instruments Department, was R. G. Ojers. One of his two editorials was entitled "Let's Get Together—Proposing a Guild of Aircraft Instrument Mechanics." When we received the material from Mr. Ojers, this particular editorial struck us as an on-the-spur-of-the-moment job and we wrote Mr. Ojers, asking just what he had in mind. As a result, he re-wrote portions of his original editorial and added three or four paragraphs, explaining that his proposed Guild would be *neither a labor union nor a new engineering society but a genuine guild*, similar to the highly-respected Watchmakers' Guild. In these new paragraphs he explained the distinctions and stated that he formerly was a watchmaker himself.

Of course we had not refused to print this appeal (we give each Guest Editor full charge within well-understood limits) but we had not been enthusiastic. Our hesitation was dispelled, however, and it was with pleasure that we featured his appeal—with pleasure and with confidence that the Guild would become a glorious reality.

It did! Soon Mr. Ojers was reporting that *Instruments* subscribers in various parts of the country had applied for membership. The Guild was formally organized in October. We received various forms and circulars. One of the notices to members ended with the mention that a Guild magazine would be started, but it was accompanied by a letter from Mr. Ojers in which he asked whether *Instruments* could serve that purpose, what rates we would charge for various amounts of space, and so forth. We replied somewhat as follows:

(1) There would be no charge—as there is no charge to the organizations which use space on our Instruments Societies Page; (2) the Guild would get space in *this* Department; (3) internal Guild affairs would appear under a distinctive Guild heading; (4) technical articles by Guild members would be treated as are all other technical articles—the only consideration being value to *Instruments* readers; (5) as with all organization under the Group Subscription Plan, any members who are not subscribers would receive *Instruments* automatically for $1 of their dues sent in groups of five or more at a time.

The material for the first Guild "sub-department" of the Aviation Instruments Department was received early in February. There was so much of it that, except for "this here column," it is the entire Aviation Instruments Department this month!

Among Guild members are outstanding experts whose articles, though written for the benefit of their fellow-members, will benefit all other *Instruments* readers.

We have some ten thousand subscribers and at present there are some two hundred members in the Guild, that is to say, 2%; but the 98% will not mind our devoting this month's Aviation Instruments Department exclusively to the Guild: already there are extremely interesting technical articles and notes which will interest the 98%. And the 98-2 ratio is today's: tomorrow it may be 90-10, then 80-20 . . . who knows?

After this month's "Guild splurge," the usual variety will be resumed and those few purely internal Guild matters which are accepted for publication will be printed in small type, as is done with the internal affairs of the industrial instrument societies on the Societies Page.

From now on, however, each Guest Editor of the Aviation Instruments Department will not have charge of *all* of it: some of it will be the Guild's . . . and we know of other claimants for space! —M. F. BEHAR, Editor of *Instruments*

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The Arrangement Between *Instruments* and the Aircraft Instrument Guild

By R. G. OJERS

President, Aircraft Instrument Guild, 812 N. Delaware Place, Tulsa, Okla.

ONE of the keenest desires of a few instrument mechanics in the earlier days was to become licensed by the C.A.A. like our big brothers, the Aircraft and Engines Mechanics, as well as the Radiotricians.

It was easy for us to see why the radio people should stand in a group by themselves but for the A and E Mechanics, to hold a special rating while the aircraft instrument technicians be left out was quite beyond our ken.

It is true, we were mere infants in swaddling clothes, and the proverbial "seats of the pants" of the pilots were the best of instruments, at least in the small or light craft, but with the advent of the two-, three- and now huge four-motor planes, it was necessary we grow up—and fast. This we did, even to the extent of growing out of our pants, so to speak. We even suffered growing pains; one group of muscles didn't know how the other group were developing, but we did know they were. The next thing that became necessary was to try to coördinate all groups that we may grow together, that we may be governed by one universal leader, *knowledge*, through interchange of experiences.

There are a number of ways we could gain knowledge. Go to school—the best way to get a start; here you could go only so far then you were shoved out on your own. Or you, as an apprentice, could sit beside an older mechanic and learn his ways, which, like the first, would take you only so far, as the older mechanic didn't have the opportunity to advance himself very much. Why? Simply because the instruments he is working on and teaching you are only a few of the large number of instruments in the average plane of today.

So why not allow hundreds of mechanics that work on hundreds of different instruments coöperate to give one another the benefit of their experiences, giving everyone the opportunity to become more proficient as well as versatile, in a line of work that is a trade in itself? This is what created the necessity of bringing these tradesmen into a group or guild.

One of the greatest forward movements to be taken by the aircraft instrument mechanics is to become recognized by the Civil Aeronautics Administration, creating a special rating to a trade that has grown in proportion to be almost unbelievable. This can best be done by publicizing the instrument mechanic and letting it be known that we are on the job.

It was not so long ago that the average pilot looked upon instruments as rather fancy and expensive gadgets, but under present conditions the average pilot refuses to take his plane off the ground if the hand on the airspeed indicator is a trifle off zero.

The Aircraft Instrument Guild has become a reality, with a charter membership enrollment of fifty-one. More than a hundred additional members have enrolled since.

While this was a local organization at the start and the charter was granted in Oklahoma, we desire it to be nationwide, and even international after the war, if not before.

Another important factor is to have some working arrangement with the various instrument manufacturers whereby an instrument mechanic will be able to obtain service and overhaul manuals pertaining to the proper overhaul and installation of all instruments. I am sure they will be more than glad to coöperate with us as soon as they know we will have proper control of the distribution.

Their objection in the past has been a fear a layman would attempt to overhaul the instruments and cause some irreparable damage and then attempt to blame the manufacturer, causing possible hard feelings between the manufacturer and the operator.

Through the classification of the mechanics in the Aircraft Instrument Guild, we can give some definite assurance of only mechanics receiving this service.

This Our Emblem

You will notice the large A, signifying the Aircraft, and the I and G on the wings signifying our instruments are used in flight. We have a sector gear on the left for standard instruments, the gyro rotor on the right for gyroscopic instruments and the two bolts of lightning for electrification of instrument indication, and through it all, we maintain precision and quality.

(Reduced size.—The decalcomania transfer for auto windshields or office windows is 4" square.)

This is an emblem that should indicate to the mechanic a goal we should all strive for—proficiency in all work pertaining to aircraft instruments, cooperation through unity of mechanics, recognition through publicity, and *attainment of perfection through persistence.* —R.G.O.

These and many other things have been lying dormant in the minds of a lot of us and they were only awaiting an "open sesame" to these interlocked desires and ambitions that we may, through some organ acting in the capacity of a heart, glean all the goodness from our vast resources of mechanics, sifting, sorting, then constructing valuable blocks of knowledge that we may have a more sturdy foundation in which to build our trade.

This opportunity was unexpectedly presented to me when I was asked to become Guest Editor of the "Aviation Instruments" department of the magazine *Instruments*. I more than jumped at the chance, as it offered me means of expressing what I know was in the minds of hundreds, yes, today I can say thousands, of other minds—our desire to create an organization which, after due consideration, we called a guild.

As a result of my article in the July 1942 *Instruments* magazine, letters have come in from the four corners of our United States, expressing interest and willingness to participate.

These letters didn't come from graduates of the Spartan School of Aeronautics only, but from instrument schools in California, New York, Illinois, Washington—from mechanics of long standing and from various airlines requesting more information. The majority of the inquiries offered complete coöperation in our endeavors; a few were skeptical, wanting to know what they could expect in return for their investment, thinking perhaps this was a union. All we can say now or later is that the benefits to be received will be just what we all make it.

We were first confronted with the difficulty of starting our guild on a reasonably sound foundation. Due to necessity, a small group of us that were permanently stationed here in Tulsa met to form a nucleus around which our guild could be shaped.

Since this time, we have been necessarily slow in growing as our various tasks had to be taken care of first, and the Guild in our spare time, of which none of us has any too much.

It was our original intention to publish a magazine of our own, but the extra cost and extra work, and lack of experience, made us wonder about the feasibility of such an undertaking when, like manna from Heaven, Major M. F. Behar, the Editor of *Instruments*, came to our rescue and offered us all the space necessary for the advancement of our Guild.

This assumption of a financial burden by *Instruments* has proved a boon in other ways. We figure that the saving of this money will allow us to encourage mechanics to write articles by enabling us to reward them for their efforts. I realize —and others helping put this over realize—that the time and work involved in getting up interesting articles that may be beneficial to our members is tremendous. Then, too, we may run out of material, or questions will be submitted that we may lack the knowledge or time to answer. By paying a sum commensurate with the problem in question, this will make everyone feel a little more like spending extra time in working out diagrams, charts and even pictures when necessary, to complete an article in a manner to be sufficiently explanatory for both the new mechanic as well as the old timers.

Brief Account of Formation of Guild; By-laws

ON October 3, 1942, a meeting was held at 920 S. Canton, Tulsa, Oklahoma, for the sole purpose of discussing the possibilities of organizing a Guild in order to further activities of interest and benefit to aircraft instrument technicians, mechanics and specialists.

Those present expressed a decided interest and a desire to begin activities toward definite organization immediately and requested that officers be elected for the purpose. Those elected were: R. G. Ojers, President; R. L. Davis, Vice-President; L. J. Harvat, Treasurer; A. J. Pfister, Jr., Secretary; and E. M. Allsman, Recorder.

October 4, 1942 was set aside for the presentation of the Articles of Incorporation and By-Laws. The meeting was duly held and resumed on October 6, 1942, at which time the Articles were signed by fifty-one charter members.

The By-Laws of the Aircraft Instrument Guild were presented for approval and adoption on November 22, 1942. After lengthy discussion and changes, they were declared unanimously adopted. They read as follows:

CHAPTER I

Section 1. NAME.—The name of this society shall be the Aircraft Instrument Guild and its principal office shall at all times be in the City of Tulsa, Tulsa County, State of Oklahoma.

Section 2. TERRITORY.—The territory to be occupied by this guild and in which local chapters may be established and maintained, shall be international, subject to such restrictions as the board of trustees deem advisable.

Section 3. MEMBERSHIP.—The membership of this guild shall consist of persons whose means of livelihood is directly or indirectly connected with aircraft instruments. Members shall confirm to the obligations prescribed by these by-laws or any amendment thereto.

Section 4. NATURE AND PURPOSE.—The purpose for which this corporation is formed is to promote and maintain a closer relationship among persons employed in the manufacture, repair, design, improvement and/or use of, aircraft instruments; and to carry on an educational program pertaining to aircraft instruments, their manufacture, repair, design, improvement and/or use; and to improve the skill and efficiency of men employed in the manufacture, repair, design, improvement and/or use of aircraft instruments; and to acquire and hold such property, real or personal, as might be necessary to carry out the purposes for which this corporation is formed.

Section 5. GOVERNING BODY.—The governing body of this guild shall be known as the Supreme Body of Trustees, who shall elect from their number the following officers; President, Vice-President, Secretary, Treasurer, and Recorder. The body of trustees shall be elected by the membership at large, either by a direct ballot, cast in open convention, or by a secret mailing ballot, as the board of trustees may from time to time direct.

Section 6. POWERS OF THE SUPREME TRUSTEES.—(A) To enact laws for their own government and protection and to prescribe rules for the procedure and conduct of the business of the guild. (B) To pass upon and determine all matters relating to the qualifications and election of its officers, committee men, chapter officers, and members. (C) To prescribe the duties or powers of its officers, committees, chapter officers. (D) To establish rates of assessment necessary to provide funds for the expense and conduct of the business and to make laws for the collection, preservation, and disbursement of funds. (E) To define offenses against the guild and to provide penalties therefore; and to amend its articles for incorporation and by-laws, by repeal or enactment, and to enact laws in any matter deemed necessary for the welfare of the guild, and to direct the execution of all powers vested in the Supreme Trustees,

Continued on page 150

Don't Scrap All the Scrap!

A Plea for Conservation of Materials and Replacement Parts; and for Ideas on Improving Workmanship

By R. L. DAVIS

Vice-President, Aircraft Instrument Guild

WHILE production for victory is the subject of the present day, we must not, through oversight, forget the fact that there is a possibility that in the future every department in the aviation industry may some day be confronted with a severe shortage of replacement parts. This is already true to some extent in various departments, and if a shortage is not noticeable, we will have to admit a great deal of delay and filling orders is a headache common among the thousands of plants now doing more than was asked, to serve our needs. Any delay in shipment of "on order" parts at the present time naturally constitutes a bottleneck in the repair departments.

Let us consider one of the most important overhaul departments in the whole aviation industry: that of aircraft instruments.

Where could you find a more logical place to require replacement parts, to prevent thousands of shop tags from being marked "Waiting for new parts"? To the shop foreman, that phrase written on an instrument tag is a disheartening sign, standing out in his mind, which suddenly makes him realize that we cannot "keep 'em flying" until he can write an "OK on final check" in the place of the dreaded "Grounded for lack of parts."

Let us not kid ourselves into believing that we will soon be relieved of such shortage of replacement parts, but instead, we will at least overcome some of those difficulties if we will take steps to meet the future demand by conserving to the limit on what material and parts the department has on hand at the present time. We believe it would be unnecessary to be reminded of this one thing. Carelessness and wastefulness are the two contributing factors that can and will cause a decided slump in departments' production in the aircraft instrument shop.

Being conservative is not the only way in which we can plan for the future. May I suggest a very important phase of being prepared by outlining a few of the many ways possible to meet latter needs. By all means, save every discarded part from each instrument that is overhauled. This is not for the purpose of saving scrap but is an all important "must" to insure the possibility of renovation later on, if and when that time comes. Regardless of the condition of any replaced part or assembly, we may find it to be a life saver some day, and will rejoice in finding, on the old parts shelf, a part that can be rebuilt or an assembly that can be switched around and put back into service the instrument being overhauled.

Any instrument mechanic is naturally anxious to put his instrument into service with as near "like new" condition as is possible to insure maximum operating service, but this can defeat our own purpose if we exceed a certain stage. Certain conditions require more consideration than others, one of them being the conditional requirements placed on certain parts or assemblies in certain instruments. But even though we are required to replace parts that are worn to a limited degree, this does not necessarily mean that the part cannot be put into working condition by a good mechanic who has acquired the sensitive touch and can use his head.

Many of the parts being replaced today could be segregated into two or more conditional classifications for future use. Later on, the foreman would be wise to give the responsibility of renovating these parts to the mechanics who are qualified to do precision work. A surprising result can be found in many a mechanic's ability to rebuild a precision mechanism. This can and should be encouraged by all lead-men. Even the apprentice workman, of which there are thousands today, have some workable ideas that should not be overlooked or "grabbed" by his or her superiors.

Why not start a "Keen Kinks Kolumn"—a column containing ideas and ways of improving one's workmanship? Everyone in the guild will have an opportunity to pass on and collect ideas of value, in repairing all types of aircraft instruments, including electrical, gyroscopic and standard.

Regardless of the nature of your idea, send it in to the Aircraft Instrument Guild office, Tulsa, Oklahoma, and it will be considered for publication. You would be able to clarify your explanation considerably by submitting a neat sketch, if possible, or a good clear picture of the project involved. We will make up a scaled drawing of your sketch to be sent to the publishing company office. (If you are even fairly good at drawing, your own original print may be sufficient. Just be sure you have all dimensions, etc., in detail.)

By telling the other fellow, through our guild section, we can soon have a nice collection of clever ideas we may find valuable to us all. What do you say, some of you old-timers and apprentices, let's get started on a real "swap an idea" section.

As an illustration, if you break the pivot on a Kollsman handstaff pinion gear, don't throw it away: a good mechanic can repivot this bit of material, saving $10.80 plus the instrument in case another one cannot be bought.

If the floating pinion of the chronometric tachometer has bad teeth, bush the floating pinion up a little and drop the center wheel and shaft assembly down through shimming, shifting the contact point on the floating pinion from the worn place to a new position, causing perfect operation.

Occasionally, on the same instrument, the corrector wheel assembly, through constant pounding, may work loose, causing the two wheels to become out of alignment, creating an erroneous reading. These can be reset and then spot welded, eliminating the possibility of their working loose again.

This we are doing to most of our new parts, as we have found it will save us a lot of "re-works."

A new approach to the problem of measuring audio frequency equipment

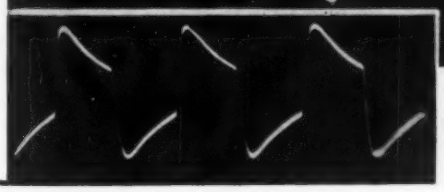
One of the most recent approaches to the problem of measuring the response of amplifiers and networks is to apply a square wave voltage and observe shape of the wave which is transmitted. The frequencies contained in a uniform square wave are given by the relation:

$$f(t) = \frac{4}{\pi}(\sin wt + 1/3 \sin 3\,wt + 1/5 \sin 5\,wt + \ldots)$$

In practice a wave which appears to be perfectly square will contain thirty harmonics or more and when the amplitude or phase relation of the harmonics is disturbed the square wave will be distorted. Thus the application of a square wave to circuit shows up any irregularities in the amplitude or phase transmission of that circuit not only at the square wave frequency but also at frequencies far removed from the test point.

The square wave test is particularly important in feedback circuits where the circuit performance outside the normal transmission band is generally of interest. The application of a square wave test to a feedback amplifier will show in a single observation whether the amplifier is close to oscillation point.

Square wave applied to two amplifiers. Output of one on horizontal plates, output of other vertical plates for rapid comparison test. One amplifier defective shows up immediately whereas without square wave a long point by point frequency response would be required to discover deviation from standard.



Square wave distortion from poor response at both low and high frequency. (Oscillogram taken on a typical public address amplifier.)

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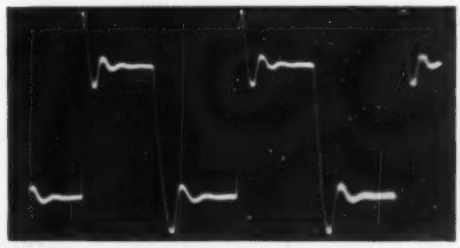
No priority needed to avail yourself of our engineering help but -hp- instruments are going all-out for war and quick deliveries can be made only to people engaged in the war effort. However, we are making prompt deliveries to war plants and our capacity for fast production is ample. Write today for information.

Square wave test on feedback amplifier showing amplification peak at 9 times square wave frequency. (A normal frequency response measurement shows flat response from 20 cps to 20 ks.)



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Probable Cause of Noise in Gyro Instruments and a Suggestion for its Prevention

By R. G. OJERS

Chief Instructor, Instrument Dep't, Spartan School of Aeronautics, Tulsa, Okla.

HOW many of you mechanics have heard the pilot say that after cutting the ignition of his engine, he sits back to see if everything is "off" before leaving the plane? He expects everything to be quiet after the roar of continuous flight has subsided, but there is a strange whine coming from somewhere.

After tracing this noise you find it is coming from one of the Sperry indicating instruments. Some of you start an argument, for you had your instruments all checked and overhauled only a few hours back, and you just know that they shouldn't be making noises like an unoiled tricycle.

I have seen pilots, thinking their instruments were lagging, beat on the panel with their hands, and in some instances they used their feet. I do not believe that there is an instrument mechanic today with even a modest amount of experience who hasn't had to change a number of cover glasses because of their being crushed inward by some kind of a severe outside blow.

If we could only realize what delicate parts are inside all these instruments! Some of the standard flight group even have ruby and sapphire jewels, just like high-grade railroad watches. How many of you would pound your watch hard enough to break the crystal? A good watch costs around $85. Your sensitive altimeter costs from $165 to $230—your gyro instruments cost much more than that—quite a lot of money to be *kicking* around.

Suppose you let us take you inside this noisy instrument and show you just what is behind the scenes. The Sperry gyroscopic instruments are just what they are represented to be: they operate on the principle of a moving force and tend to maintain rigidity in space. This is a complicated bit of physics which limited space will not allow us to explain. The Sperry company has utilized this principle in a way that has proved a boon to the pilot. In the auxiliary horizon or flight indicator, there is a brass wheel or rotor that weighs eleven and three-fourths ounces. This rotor makes between ten and twelve thousand r.p.m., which is really a tremendous speed. To have this unit operate under normal working conditions, it is necessary for everything to be perfect. The bearings, races, balls and pivots are made from the highest-grade steel obtainable and require a special oil for lubrication, one that will stand up against a perfectly balanced rotor of this designed weight, running at high speed from 400 to 1200 hours.

You ask, "What has all this to do with that terrific roar we hear in the instrument. What is the cause of that?" When we have explained the research that we have conducted, you will know.

Let's go back about seven years, when the writer and possibly a hundred other aircraft instrument mechanics with experience on Sperry instruments (about all there were in the United States at that time), encountered the condition of burned-out rotors. At first we blamed the trouble on our procedure, but numerous experiments proved this assumption to be erroneous. After several years of trial and error, we came to this conclusion: there were two seasons during which we could look for this trouble: the early fall and early spring, each period lasting approximately forty days. We learned also that we could duplicate this burned-out condition to perfection whenever we desired. But how could it be eliminated?

We have worked for several years on the assumption that there is tannic acid and salt in human perspiration. Could it be that the instruments brought into the shop were impregnated and affected? The perspiration factor can be practically eliminated by air-conditioning. Medical authorities tell us that tannic acid is non-soluble and is not thrown out through the pores in the form of perspiration. Consequently the tannic acid came from some other source.

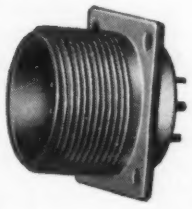
As an illustration, a doctor trying to find a cure or antitoxin for a disease isolates the germs, then conducts exhaustive research to find the cure or counter-agent. This particular germ may break down the tissue, bone structure, blood corpuscles, or some particular organ. Now, like the doctor, we can duplicate this ailment to permit an analysis or diagnosis; and we know that, like hay fever, it is predominant at certain times of the year. Is this germ tannic acid or phenol?

We have a clue because we already know that these instrument failures occur only twice a year; early spring and early fall. There is a high content of tannic acid in trees, shrubs, bushes, and foliage of all kinds. In the early spring when the trees bud profusely and rains come to beat the buds to earth where they are crushed by tires or human feet, the rain makes a fine strong "tea," full of tannic acid, and the fumes are carried off through the air. This is repeated again in the early fall when the sap starts going back into the ground: the leaves fall, become water-soaked, and are crushed. More "tea," more tannic acid. This sounds logical, doesn't it?

Well, here is some more logic. In the early fall and early spring, people have more colds than at any other time. When we have colds, we take a lot of aspirin. Medical authorities tell us that aspirin has a high content of phenol, which is essential in the making of carbolic acid. This phenol is thrown out of the system through pores, as perspiration.

The writer was formerly connected with one of the major airlines which had air-conditioning, but it was heavily overloaded. Cool air was brought in, but the circulation was such that the moisture was not drawn from the air. I mention this as a comparison, because on the average one of every six Sperry instruments brought through the shop will be burned out. In the Spartan laboratory we overhaul approximately fifty Sperry instruments a month. During the last spring season we had seven burned-out rotors, whereas last year, with half the present personnel, we ran through twenty Sperry

The man who flies by instruments must have confidence in the various devices that guide his flight and keep him informed on the performance of his plane. Yet that confidence can be no greater than the dependability of the electrical connectors used in the instrument circuits. He seldom stops to think about the part played by these connectors, but when he does, his request is always the same . . . "No bad connections, please!"



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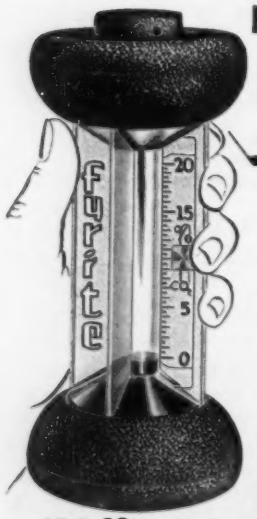

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instruments and had twelve burned-out rotors. This means that the years of research and our many trial-and-error methods of "barking up the wrong tree" finally led us to the right tree, so to speak.

Considering this, you will find that most of the up-to-date instrument department laboratories and schools throughout the country are using air-conditioning, with refrigerant units. The human body throws off into the air a minimum of approximately 0.75 quart of perspiration in twenty-four hours, or half a pint per eight-hour workday. This moisture, as well as the normal moisture content, must be removed from the air in an instrument laboratory. As an example, in our department, with seventy-four students and eleven employees, a total of eighty-five people, a minimum of twelve gallons of moisture (including about three gallons of human moisture) must be taken care of by our fifteen-ton-capacity refrigeration plant during an eight-hour day.

It is our opinion that if we are careful to keep the bearings clean and free from any of these elements while being overhauled in the shop, quite a bit of this trouble will be prevented, although there is still the possibility that the instruments may breathe contaminated fumes while the plane is in flight or taxiing on the ground.

Do not get the erroneous impression that we believe we have the situation completely in hand. To date, this has not been accomplished by anyone. We are trying to show the extent of the research and efforts put forth to eradicate this disease. Disease is just what it is to the operators, for it is eating away at their profits from two angles: in costly replacement of parts, and in expensive labor. There is also the waste of man-hours which, in these days, could better be applied to inspection and repair.

Experiments with special filters have been tried, but the only method that can prevent this devastating plague is the one that will truly condition the air going into these instruments while they are in operation. It would be necessary, first to wash the air to remove insoluble dirt and chemicals, then to freeze the air to remove moisture and soluble chemicals and acids, then to warm the air again before sending it to the instruments. The equipment necessary to handle a volume of air sufficient to operate these instruments would weigh from one to two thousand pounds. Yes, you are right—this load would be completely out of the question for even the larger aircraft.

Experiments are being carried on with high-frequency current and charged screens. This scientific method will attract all particles of dust, even to the smallest particle of smoke; but this equipment will not withdraw moisture, and consequently will not remove the tannic acid or the phenol, or whatever unknown chemical enemy is causing the trouble.

The Sperry instruments are by no means the only reason for all this super air-conditioning of our instrument laboratories. The high quality of steel used to make pivots and pinions in the standard instruments is just as susceptible to rust, but the corrosion is more easily controlled because in these units there is not the volume of circulation

of air that we have in the Sperry group instruments.

We believe that if the average pilot would make a study of aircraft instruments as he does engines and aerodynamics, he would have a much greater respect for them, since he at some time or other must necessarily depend upon their proper functioning and true indication.

Your Sperry instruments are designed to withstand a normal amount of vibration of the proper magnitude. The entire panel is even mounted with specially designed shock mounts to eliminate the wrong kind of shock, but can scarcely be expected to take a beating from an impatient pilot who does not realize the damage that he can do to them.

Remember, there is much more in your instrument panel than the dials, hands and pointers which you see.

Methods of Eliminating Noise in Gyroscopic Instruments

By R. G. OJERS

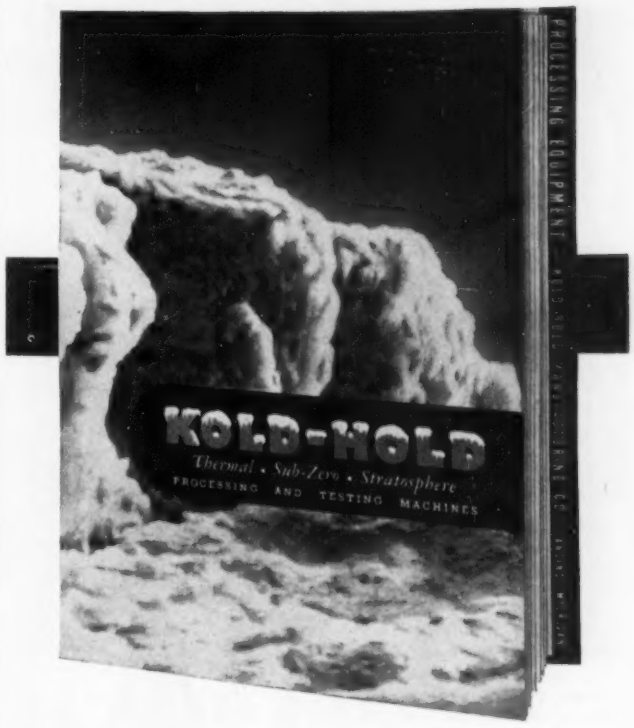
Chief Instructor, Instrument Dep't, Spartan School of Aeronautics, Tulsa, Okla.

THE surge or pulsating sound of a rotor of a gyroscopic instrument, whether it is the flight indicator, turn indicator, or either of the automatic pilot instruments, contributes more theoretical headaches to the average mechanic, especially if he or she be of the new vintage. I have encountered numerous old timers who were unable to understand the idiosyncrasy of this sound or condition (we may call it a condition as it has both sound and a slight roughness to the touch) of this gyroscopic rotor revolving at high speed.

Opinions differ greatly as to corrective measures. Some mechanics say definitely to change races, change balls, or hard lap the pivots a little more; while others claim they have little trouble and, when they do, they pass it off as a natural condition and let it go.

I am inclined to agree with the latter to a certain extent, i.e., unless it is an extreme condition, it will cause no harm. The writer is keeping a record of an artificial horizon in one of the Spartan Executives that has approximately 600 hours of flight. When the motor is shut off, there is a pronounced pulsating sound that, as near as we can tell, has remained the same as the day it was installed. Likewise a record was kept of several gyro instruments on airliners in like conditions. They were released from the overhaul shop with a pulsating sound. These instruments have given satisfactory performance for 400 to 900 hours without any change of conditions other than normal wear. One burned out its rotor in twelve hours, but we have had instruments burn out in four or six hours. In fact some even burned out while being calibrated and had no pulsating sound. So we do not list that in our experiments.

Now for you mechanics who have supervisors or foremen who may differ with this opinion: perhaps you would be interested in knowing our meth-



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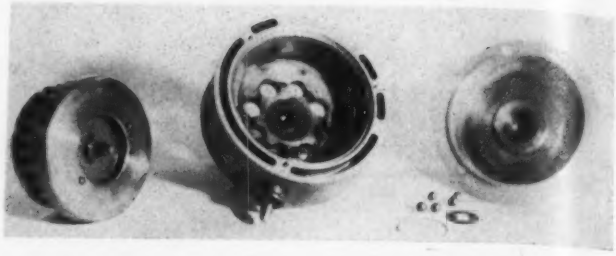


od of eliminating this "curse," as some call it. We know it to be a condition where both bearing-assembly and pivot are out of concentricity, each having its own peculiar destined howl or whine; but they will be of different pitch and out of synchronization, hence the expression "surge." When we speak of the bearing-assembly and pivots being out of concentricity, the bearing itself may be ground out-of-flat, or a tiny shaving of metal or small particle of dust may be caught under one side of the bearing, causing it to seek a cocked position, or the pivot may be ground a little off center, or you may have one or more balls a little out of round, or there may be a combination of all three. The latter is an extreme case and extremely difficult to correct. For instance if the pivot has been ground off center thirty to forty-five strokes with the hard lap, then finished off with the soft lap, the use of standard Sperry compound as an abrasive will usually do the trick. If the bearing is the cause, first check to see that this bearing seat is clean, then turn the bearing just one-half turn. Often this procedure will solve the problem, but occasionally a new set of balls is all that is needed. However, as we have mentioned, under extreme occasions we may have to do all three.

A little trick that works wonders sometimes is to run the rotor up to full speed and while it is in the housing or gimbal ring (if it is the directional gyro rotor) grasp it firmly in one hand and twist the assembly in a circular motion until its gyroscopic force causes it to growl. This will tend to create excessive pressure, forcing the bearing assembly to seat more firmly. If, for instance, we failed to seat them properly at first, or if a small particle of dust is holding the race out of flat, this action will cause the dirt to break up or embed itself in the side. In the case of a spring-loaded bearing-assembly, be sure the bottom of the race fits flat on all four springs. This corrects a fault which causes more trouble than all the rest.

The A.I.G. Q&A Column

Conducted by EVERETT M. ALLSMAN, Recorder, Aircraft Instrument Guild

It has been suggested, and we heartily endorse the idea, that provision be made for a Questions and Answers column in the Guild news. Why not address your opinion and questions to the author in care of the Guild? As a starter we are giving a few questions which have been brought up by members. —E.M.A.

Q. Through what temperature ranges are aircraft instruments compensated?

A. In general aircraft instruments are compensated to assure correct operation within limitations throughout a temperature range of —35°C. to 60°C. This means that the instrument may be considered safe, accurate, and reliable

insofar as effects of these temperatures are concerned. Naturally some instruments must be subjected to more exacting temperature tests, e.g., the airspeed indicator which is checked at —35° and plus 70°. with an average tolerance of ±2 m.p.h. in excess of the scale error tolerance.

Q. How are instruments protected against airplane vibration?

A. To eliminate vibration, which may be excessive, all instruments panels are shock-proofed to minimize the amplitude and frequencies of vibration. The general method is to mount the entire panel on rubber shock-absorbing mounts which are used in pairs: one being attached to a fuselage bracket and the other fastened to a panel bracket. The airplane manufacturer at the time of installation determines the proper size and location of each absorbing unit by dividing the total weight of the panel and instruments by the number of suspension points and ascertaining that they pass through the center of gravity of the panel. Neither sponge rubber nor springs should be used. Periodic inspections are required of each mount and if replacement is necessary it is imperative that the proper size is used. The inner ring of the cup is always stamped with the load rating. Incidentally, shock mounting is not intended to eliminate all vibration but rather to keep it at a minimum.

Q. How does differential vibration between the panel and fuselage affect the necessary connecting lines?

A. Provision is made for the difference in vibration by the use of a flexible line at the rear of the instrument when tubing connections are necessary. This may be accomplished by means of a length of pressure-resistant synthetic rubber tubing equipped with necessary fittings. If this is unavailable, a coil may be made in the tubing close to the instrument, care being taken not to use a radius less than 1½ inches.

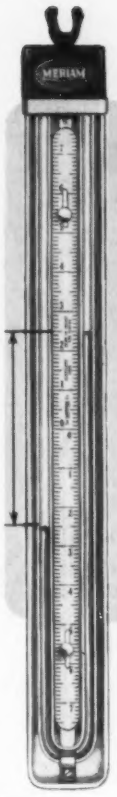
Q. Why is it necessary to check the zero setting error of a sensitive altimeter? How and when is this done?

A. During normal usage the aneroid (sealed capsule) of the sensitive altimeter is continually expanding and contracting. This relentless flexing results in metal fatigue and characteristics are established which change the relative relation between the aneroid and the pointers. This change is neither "hysteresis" nor "recovery" but, on the other hand, is to be expected with normal operation. Thus it becomes imperative that we periodically inspect the instrument for the resulting error.

This inspection and the possible necessary adjustments are carried out as follows, approximately every fifty (50) hours:

A portable altimeter is first checked against the station altimeter with the pointers of both instruments set to indicate surveyed elevation and scale corrections noted. The barometric indications should be identical and, if any discrepancy is present, the portable should be set to agree with the station altimeter. This is normally accomplished by loosening the screw just to the left of the setting knob and displacing it to the left. Now pull out on the setting knob, thus disengaging pointer movement, and turn it until the "altimeter setting" (existing atmospheric pressure reduced to sea level in inches of mercury) reads the same as that of the station altimeter. There is no allowable tolerance and the scale should be read to at least the closest hundredth of an inch. After corrections have been made, vibrate both instruments and check to be sure that there is no error.

Now take the portable altimeter to the plane. Set the barometric dial of the instrument to be checked, to 29.92" (or the reference markers to zero) and determine the scale correction for the pressure altitude. Read the portable altimeter, algebraically add the above correction and set the pointers of the airplane altimeter to the resultant figure, being sure to vibrate the instruments when taking readings. The barometric scales should now agree, i.e., they should indicate existing atmospheric pressure reduced to sea level. If an error exists, it will be necessary to correct the instrument in the panel as explained above when checking the portable with the station altimeter. Remember, there



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is no tolerance when the altimeter is equipped with a barometric or pressure setting scale.

When checking the zero setting error on instruments not having the barometric dial, proceed as above but use the field elevation pressure system setting the pointers to zero and compare the pressure altitude as indicated by the reference markers. This reading must be within thirty feet (plus or minus) of the pressure altitude as indicated on the station altimeter. Do not neglect to consider the corrections on the scale correction cards of the airplane and station altimeters.

It may seem peculiar, but errors are most common in new instruments or old altimeters equipped with new aneroids.

An instrument mechanic from Georgia writes in that their department has had extreme difficulty in obtaining sufficient vacuum differential in the Mark IV Sperry automatic pilot gyro. Some of you mechanics who have had considerable experience on this unit, please come to our aid.

Organization; By-laws

Concluded from page 141

its officers, and/or committees. (F) To grant and evoke charters of chapters. (G) To provide by law for the impeachment, removal, or suspension from office of its officers, delegates, and/or committees.

CHAPTER II

Membership Classes and Qualifications

Section 1. The membership of this guild shall be divided into four classes. *Class number one:* (A) Master Mechanics. (B) Specialists. *Class number two:* (A) Instrument Mechanics. (B) *Class number three:* (A) Junior Mechanics. *Class number four:* (A) Associate Members.

Section 2. Definitions.—*Master Mechanic*—One who has worked at the trade of aircraft instruments seven years or longer, covering the majority of all types of aircraft instruments.

Master Mechanic Specialist.—One who has worked at the trade seven years or more, only on a restricted number of aircraft instruments.

Instrument Mechanic—One who has worked at the trade for three years or longer, covering the majority of aircraft instruments.

Instrument Mechanic Specialist—One who has worked at the trade for three years or more, only on a restricted number of aircraft instruments.

Junior Mechanic—One who is just starting in the field of repair and overhaul of aircraft instruments.

Aircraft Instrument Associate—One who makes his living either directly or indirectly through the medium of aircraft instruments, such as writer, instructor, or executive, but does not have actual contact with the overhaul and repair of aircraft instruments.

Section 3. If a member is called into the service other than aircraft instruments, he will be inactive but will receive all benefits at no charge until his release. However, this time will not be applicable toward a higher rating. Provided that he is actively engaged in aircraft instruments, his status will be identical with the civilian mechanic, including the payment of yearly dues.

CHAPTER III

Fees and Dues

Section 1. The initial initiation fee of members of all classes of members until further changed by the Supreme Board of Trustees, shall be five dollars per individual. The initial dues of all members until further changed by the Supreme Board of Trustees, shall be three dollars per year per individual.

Section 2. In the case of any monthly publications such as a magazine printed by the Aircraft Instrument Guild, such shall be mailed to all members free of charge.

COPY (SLIGHTLY ABBREVIATED) OF OFFICIAL INVITATION TO PROSPECTIVE MEMBERS

AIRCRAFT INSTRUMENT GUILD

INTERNATIONAL HEADQUARTERS

812 N. DELAWARE PLACE
TULSA, OKLAHOMA

Dear Friend:

The Aircraft Instrument Guild is now a concrete organization, having received its charter October 23, 1942, with an enrollment of fifty-one charter members.

We wish to take this opportunity to invite anyone interested in an organization of this type to complete the enclosed application.* This will inform us as to your eligibility and to the classification under which you would be listed, such as:

MASTER MECHANIC
MASTER MECHANIC SPECIALIST
INSTRUMENT MECHANIC
INSTRUMENT MECHANIC SPECIALIST
JUNIOR MECHANIC
AIRCRAFT INSTRUMENT ASSOCIATE

The purpose of this guild is to band together all mechanics of the aircraft instrument industry into one unified body to enable us to broaden our scope of knowledge and to be more conversant and proficient in this ever advancing and broadening field that has only recently come into its own. Unless we all pool our resources of knowledge and experiences, the field will be a dense jungle that only a few will have penetrated.

We are fairly confident that since we have our hands full with our present work, there should be no need of further research, but in this idea we are defeating our purpose twofold: First, to ourselves, inasmuch as the trend may change overnight and we will be left with empty hands; Second, we are taking the line of least resistance (which is a common fault of so many of us), in that we are doing nothing to further this field of aircraft instruments.

We would like to gain recognition with the Civil Aeronautic Administration so that we may be given a rating and become licensed.

We wish to gain recognition among the aeronautical industries that this is one department that is making every effort to better ourselves and not to just sit back and wait for the manufacturing engineers to tell us what to do next.

Let us assure each and every one of you that this is in no sense a political or union organization, but purely an educational guild whose headquarters are located at 812 North Delaware Place, Tulsa, Oklahoma. We are likewise anxious to have local guilds formed in your immediate locality as soon as sufficient members are enrolled. We would appreciate your showing this to anyone you think may be interested and contact us for information.

This guild will be made up of members associated with aircraft instruments as mechanics, engineers, writers and instructors, and honorary membership will be given to a few at the discretion of the Board of Trustees.

Our purpose is to gather all people earning, or in training to earn, their livelihood in the aircraft instrument field into a group for mutual help and assistance in furthering the advancement and knowledge in the repair, overhaul and efficiency of all aircraft instruments.

INITIATION	$5.00
DUES PER YEAR	3.00

A. J. PFISTER, JR., *Secretary.*

R. G. OJERS, *President.*

*For application forms, write to the headquarters of the Guild, 812 N. Delaware Place, Tulsa, Oklahoma.—Ed. *Instruments.*

End of Guild Dep't

Recently a new type cathode-ray tube was called for by our armed forces. Just an idea—something arising out of new conditions—not yet reduced to actual practice—and of course far from production.

Opinion generally was that this new tube might require months to develop, design, produce. Yet DuMont, with its exceptionally close coordination of experimental tube work and actual production, was actually shipping that very tube in quantities within 10 days!

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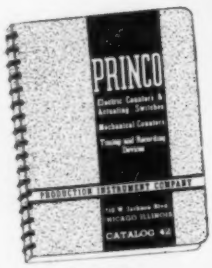

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Instruments in the War Effort

Star Projector for Training Aerial Navigators

As an aid in teaching celestial navigation to the rapidly expanding aviation personnel at a Naval Air Station Ground School, a new star projector has been built by Bausch & Lomb which projects 145 navigational stars on a spherical dome, providing a means of identifying these stars by their position and degree of brightness.

Since the stars appear realistically in the sky through a period corresponding to a 24-hour cycle, instruction is speeded up. The instrument can be used in the daytime when no stars are visible and it can be operated at night when bad weather obscures the stars outside.

At the center of the instrument is a light source surrounded by a concentric sphere, 3¼" in diameter, in which 145 minute pinholes have been drilled in three different sizes, 0.003", 0.005" and 0.007", representing three different star magnitudes.

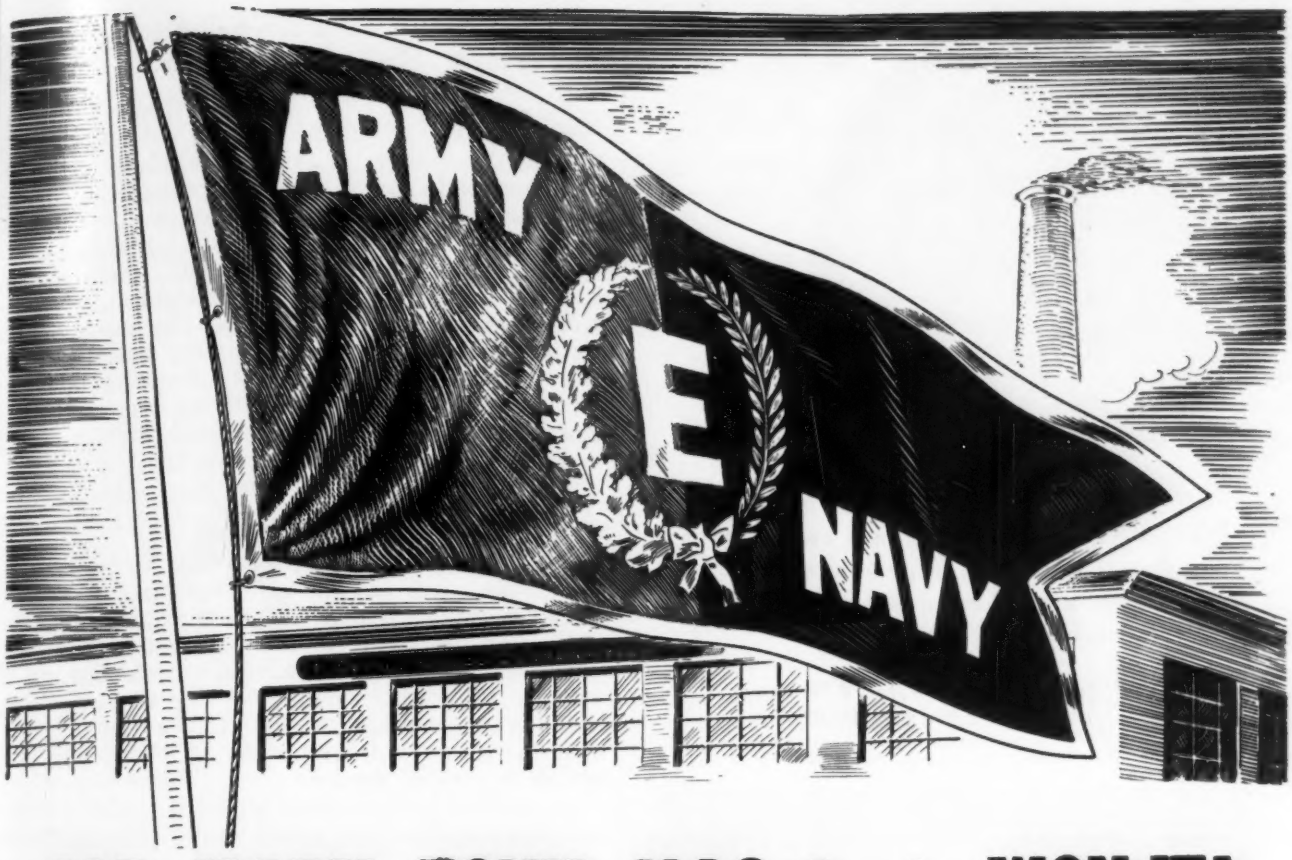
Surrounding this inner sphere is another larger one, 25¼" in diameter, containing 145 lenses each one of which lies along the same radius as its corresponding pinhole in the inner sphere, so that each star is projected along a radius at its proper azimuth and declination. A stationary hemisphere surrounds the lower half of the spheres and conceals the stars as they reach the horizon.

The light source and the two spheres rotate as a unit about an inclined axis which is tilted so that the stars appear as in the actual sky at the latitude where the instrument is in use.

Causes of Errors in Aircraft Exhaust Gas Temperature Measurements

Results of studies conducted during the past two years in General Electric laboratories to find an accurate means of measuring aircraft exhaust gas temperatures were described by W. J. King, of the Company's supercharger engineering department, in a recent ASME paper. The studies were chiefly concerned with the factors affecting readings of thermocouples in gas streams at temperatures of 1200 to 2000°F. According to Mr. King, errors of as much as 200° at 1800°F. with unshielded thermocouples mounted in bare pipes were due chiefly to intense radiation from the couple to the pipe wall. Calculations and tests showed that this error at first diminished as the gas velocity was increased, but that it might subsequently increase at extremely high velocities due to kinetic energy effects.

Mr. King described several types of shielded thermocouple mountings developed to reduce this error to the practical minimum consistent with reasonable size and weight. Tests with one of these, a small quadruple-shielded type, showed that the error will not exceed 20° at 1800°F or 10° at 1200°F with air or exhaust gases at velocities of 100 to 400 f.p.s. in a bare pipe. The wires of this thermocouple are No. 18 Chromel-Alumel, insulated by porcelain tubing protected by a metal sheath. A high-temperature alloy known as KA2SMO (18 & 8 stainless stabilized with moly) has been found satisfactory for the metal parts. Mr. King said that this type of mounting has been used in a number of applications for both flight and ground testing during the past year and has given a good account of itself, from the standpoint of practical serviceability as well as consistent accuracy.



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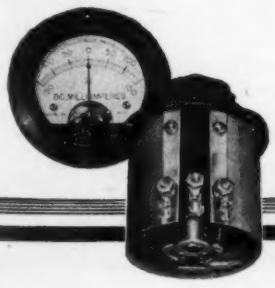

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H-B THERMOMETERS

Versatile Table for Calibration of Electrical Instruments

Concluded from page 120

potential terminals of the resistor being used. After taking one reading, both toggle switches are thrown in the opposite position, thus reversing the current and voltage by means of the relays. The high-resistance potentiometer is rebalanced and the pointer set on the point being calibrated, and the current measuring potentiometer balanced.

Locking buttons or keys for the galvanometer switch on the potentiometer were found a great convenience. Since the potentiometer could be set at a predetermined value, the galvanometer key closed at an approximate balance and the same hand used to balance the current, leaving the other hand completely free to record the calibration.

CONCLUSION

This equipment set up has been in use for the past three years and has given satisfactory service. It has been highly practical in that any variety of the aforementioned instruments can be readily checked without having to have to make any special set-ups. By simply turning two or three switches, one can go from one extreme to the other, such as from a 15-mv. millivoltmeter to a 150-amp. ammeter in several seconds.

A possible improvement would be to incorporate another toggle switch which would operate a relay at the output of the volt control box. Easy access to the wiring is another improvement that should be incorporated in any construction of this type. This could be accomplished by mounting the horizontal board on top of the panel board on hinges, thus obtaining access to the back of the panels. Provisions for controlling a source of alternating current and calibrating electrodynamic type transfer instruments for the calibration of a-c. instruments directly on alternating current are promising improvements. A powerful light source, to give considerable contrast in the galvanometer light beam as compared to the light in the room, is an absolute necessity. The illumination upon the instrument is of prime importance, in order to be able to set the pointer accurately. A 5" reading glass supported at the end of a desk lamp, goose neck and stand, with a small 15-watt tubular lamp, mounted in a shade alongside of the reading glass, has served quite well for this purpose.

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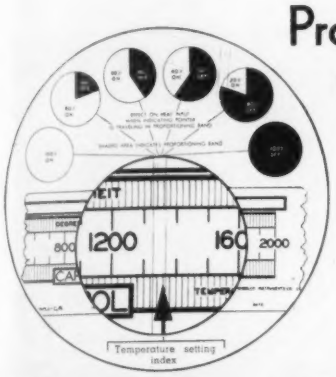

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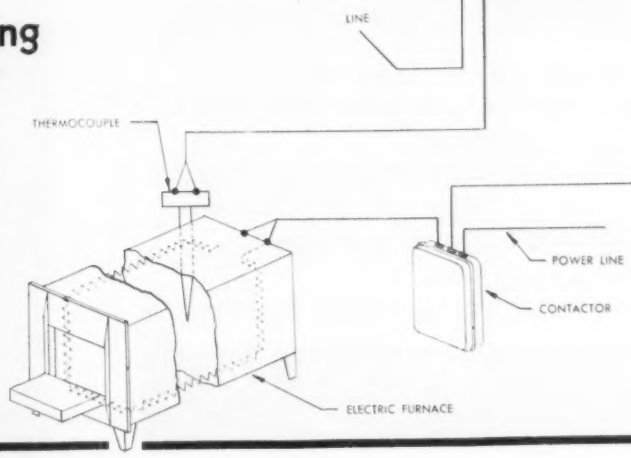

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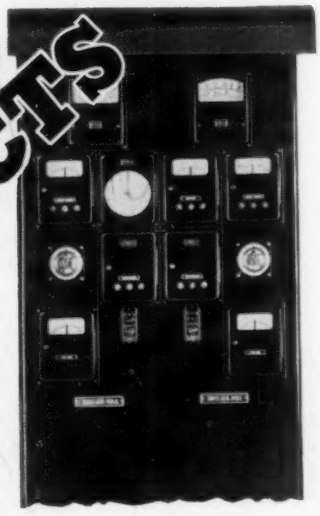

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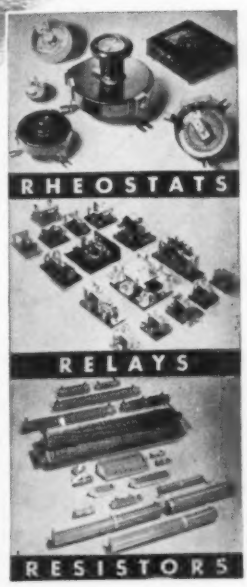

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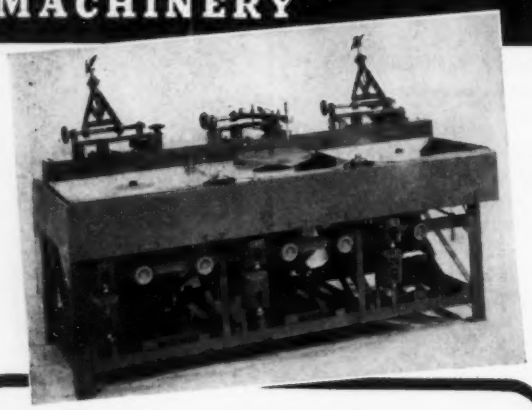

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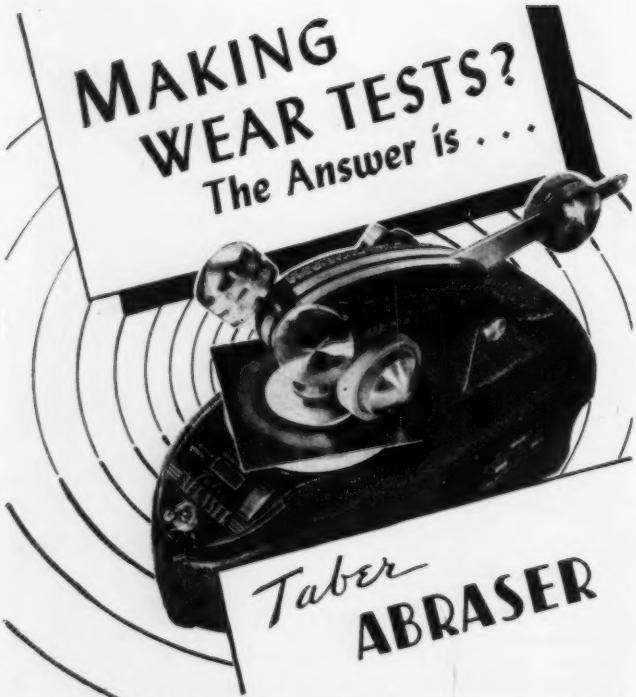

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Concluded from page 128

parts of the string supporting the load at D, two lines are drawn parallel to the strings, and whose lengths are $AD = 52$ cm. and $CD = 45$ cm., then those two lines are the vector representation of the two forces 5.2 kilograms and 4.5 kilograms. On these two lines, form the parallelogram $ABCD$, then the diagonal BD will represent the resultant of the two forces AD and CD. On measuring this line BD it will be found to be about 40 cm. long or representing a force of 4.0 kilograms which is exactly the load hung on the cord at D. This is a graphical procedure.

Again, in Fig. 9 are shown two masses, M and M', hung on cords which run over the pulleys to A and C. Light wooden strips with scales on them form the lines AD and CD. By means of the two strips AB and CB a parallelogram

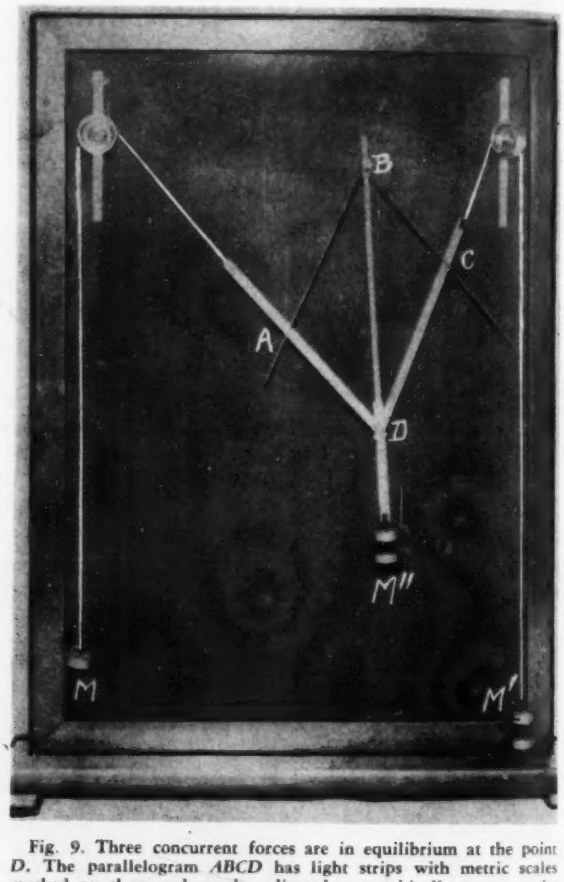

Fig. 9. Three concurrent forces are in equilibrium at the point D. The parallelogram $ABCD$ has light strips with metric scales marked on them and can be adjusted to graphically represent the magnitudes and directions of the three forces.

may be formed and by slipping the clamp B along the strip, BD, the lengths AB and CD may be made proportional to the masses M and M' and when so arranged BD will measure the resultant M'. This again is a graphical procedure.

In both cases, if we know the angle between AD and DC we can make use of the trigonometrical relations and calculate the value of BD, the resultant of AD and DC.

See pages 36 to 40 in *Foundations of College Physics* by the author, hereafter simply referred to as "Text."

A third demonstration of three forces in equilibrium is found in the crane, Fig. 10. A mass B is the load which produces a compression in the spring dynamometer boom DF and an elongation of the guy spring dynamometer DE. Both spring dynamometers can be read and when represented by vector notation as in the lines $D'E'$, $D'F'$, and $D'B$ we have at D three forces in equilibrium. Not only do we know the magnitudes of the three forces but they are represented in magnitude and direction by the length of the sides of the

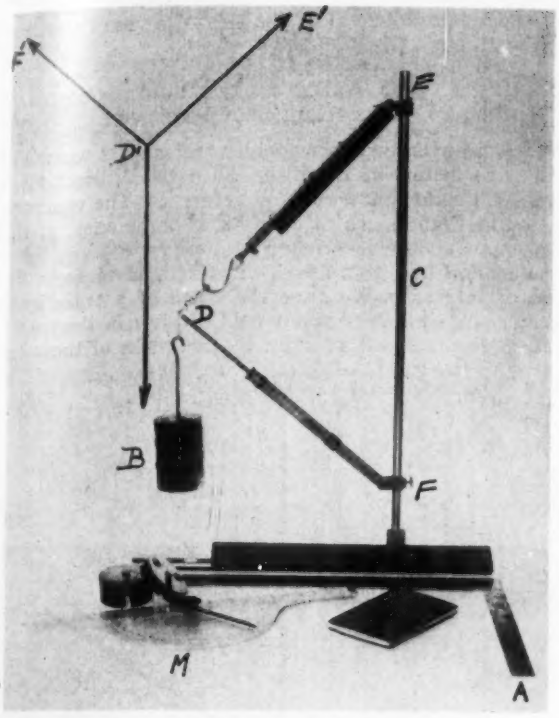

Fig. 10. Crane with accessories, *C*, *A*, carpenter's square, *M*, gravity protractor, and *B*, standard masses.

triangle *DEF*. These can be measured. Also if the angle *EDF* is made a right angle, or any known angle, we can easily calculate by the sine law the values of the other two angles of the triangle.

Check this demonstration with the first and third parts to Experiment I in *Experimental Physics* by the author, hereinafter referred to as the "Manual."

How does it happen that we can represent vector quantities by a graph of lines? Is it not due to the way in which we have set up our frame of reference in terms of lines along three directions—at right angles to one another? In all cases it is well to remember that all the conventions of geometry, trigonometry and other branches of mathematics carry over into Physics.

In Fig. 11 is shown a force table on which any number of forces acting at a common point (concurrent forces) may be shown to be in equilibrium by the fact that the ring at the center of the circular disk does not need to be held by the pin when the vector sum of the components of the forces in any direction is zero. The explanation for this

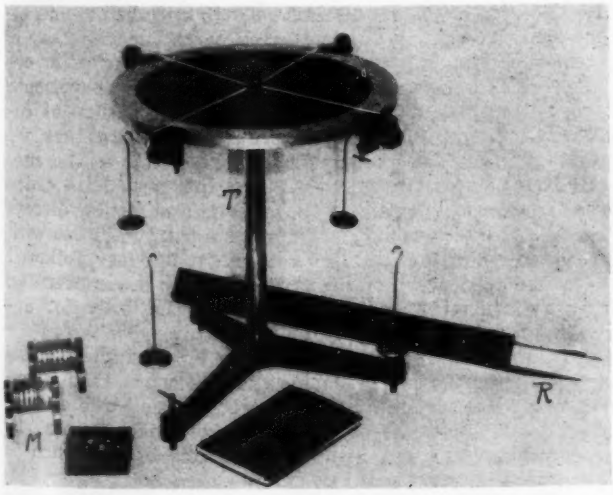

Fig. 11. Force table with standard masses and accessories. *T*, Force Table, *M*, Standard Masses, *R*, Slide Rule.

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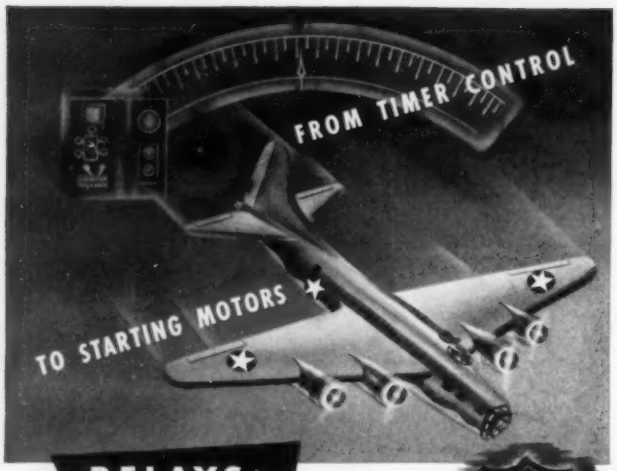

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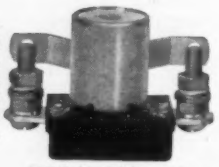

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point and the conditions for the equilibrium of any body is fully described on page 37 of the "Text" and in Experiment I in the "Manual."

Demonstration of a System of Rectangular Coördinates and Other Systems of Reference

We live in a three-dimensional world and if we wish to describe the motion of a body in all possible directions we must set up some framework or reference. The commonest is shown in Fig. 12, which consists of three axes, at right angles to one another.

Both motion and rest are always related to some fixed system of reference. We gage the speed of a train by the telegraph posts which pass our field of view in the train or we can gage the speed at night by the clicks of the wheels

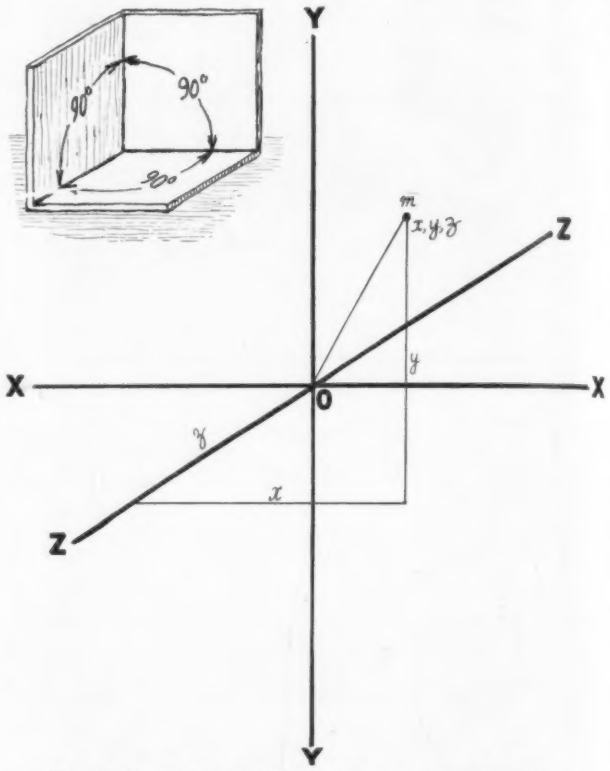

Fig. 12. Rectangular Coördinates. The mass m is located at a point 0 which is at the origin of coördinates. x,y,z present a unique point in space so far as our axes of reference are concerned.

on the rail joints. On most measuring instruments there are zero points, relative to which our readings are made. Relativity was not unknown before Einstein's contributions on the subject. Under the followers of Ptolemy the fixed system of reference was set up in the Earth and the motions of other celestial objects were referred to this system, say a system of rectangular coördinates, or a system of polar coördinates. This gave very strange paths to the movements of our sister planets. This was a geocentric system of coördinates. Then Copernicus introduced the idea that we should establish our fixed systems of reference in the sun, make it a heliocentric system. When this was done, order came into the movements of the planets and Kepler discovered that the planets moved around the sun in ellipses with the sun at one of the foci. It was a great discovery, followed by Newton's discovery of the inverse square law concerning the gravitational attraction of one celestial body for another.

Next, Einstein extended the picture by raising the question,—Suppose the sun is moving through space, then where shall our fixed system of reference be set up? The answer seems to be,—absolute motion through space cannot be measured because we have no fixed axes of reference to which we can refer such motion. We need not go into further discussion on this subject, but the study of mechanics to fulfill its objective must make use of reference axes to

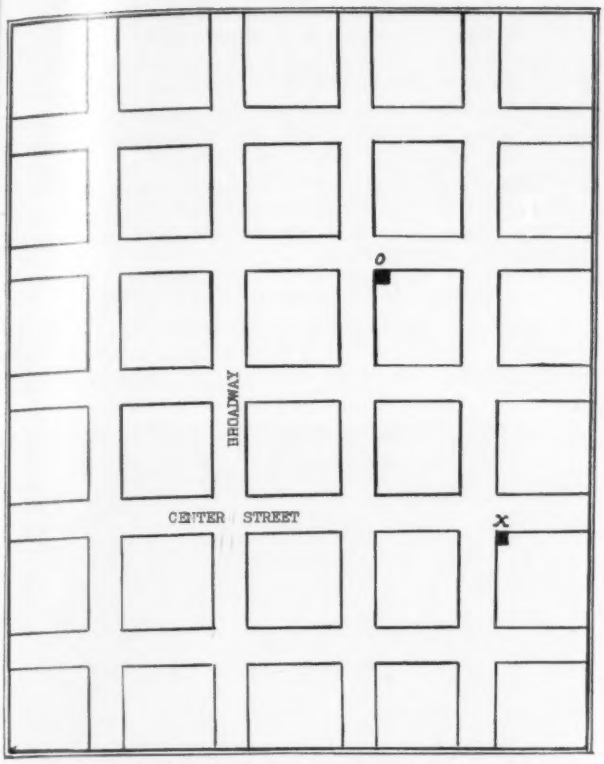

Fig. 13. A city is laid off on a two-dimensional plan. The two main streets form the axes.

describe the motions of bodies in our physical universe, for motion must be in respect to some reference system.

A common system of reference is found in laying off the buildings in a city by means of squares or streets, a two-dimensional system. See Fig. 13. In asking for directions to find a certain place we are told so many blocks east and so many south will bring us to the desired point, but it is with respect to the point from which we are directed, our zero point, that we proceed by our blocks or streets of reference.

The very simplest principles taught in Physics are reducible for the most part to a mathematical statement, and in such form can be visualized by a graph projected on a sheet of coördinate paper, which is a two-dimensional system of reference. For instance, Boyle's Law says that the product of the volume and pressure of a gas is constant at constant temperature. It helps us to visualize how the volume changes with the pressure applied if we can see the pressures plotted against the corresponding volumes. The curve is a hyperbola. See Fig. 14.

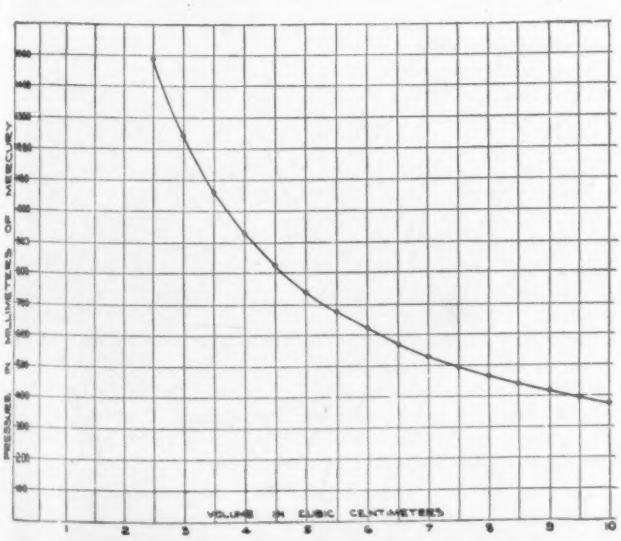

Fig. 14. The relation between pressure and volume of a gas. *(Courtesy Central Scientific Co.)*

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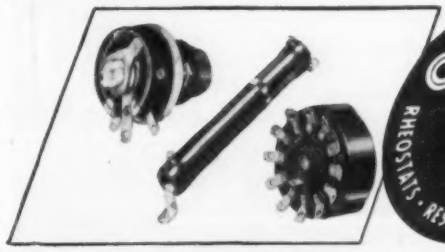

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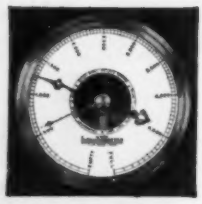

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Demonstrations of a Parabolic Path

In the curve which illustrates the path (trajectory) of a projectile, Fig. 15, which is fired horizontally, it is well to remember that the same motions are being compounded

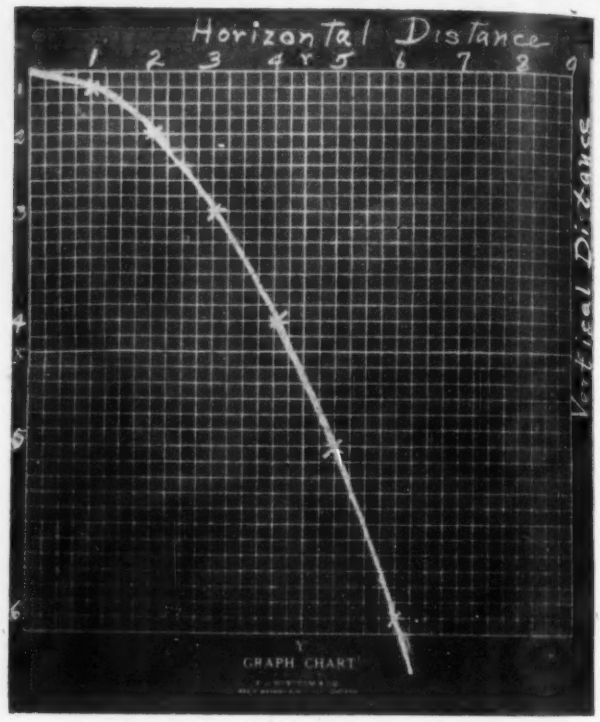


Fig. 15. A parabolic curve is obtained when uniform horizontal motion, $d=vt$ is compounded with uniformly accelerated motion, $d=1/2\ at^2$ when at right angles to the first.

even when the projectile is fired from a gun set at any angle. In any case, the moment the projectile leaves the muzzle of a gun it begins to fall. The two motions, one uniformly accelerated in a vertical direction due to gravity, and the other with uniform velocity horizontally act quite independently of each other. This is demonstrated by the outfit shown in Fig. 16. Although the gun is pointed upwards, the path of the projectile remains a parabola along *MbT*. A spring-gun fires a wooden projectile. If the force of gravity did not act on the bullet it would go in a straight line from *M* to *D* and hit the dog hanging by a bit of iron in its ear to an electromagnet. When the bullet actually leaves the muzzle of the gun it breaks the electric current of the electromagnet and both bullet and dog begin to fall simultaneously. Inasmuch as the motions are quite independent of each other the dog is hit (sure fire!) in mid-air on the line *MbT*. The gun is about the size of an average shotgun and shoots different sized wooden bullets 5 to 10 centimeters long and about 2 centimeters in diameter. In Fig. 16 the gun is shown close to the dog. In actual use the gun should be at one side of the lecture room and the dog near the other side, say 15 meters apart.

In Fig. 17 is a trough down which a wooden, glass, or ivory ball rolls. When it leaves the trough it is projected horizontally with uniform motion and then rolls with accelerated motion in a direction at right angles to the projected

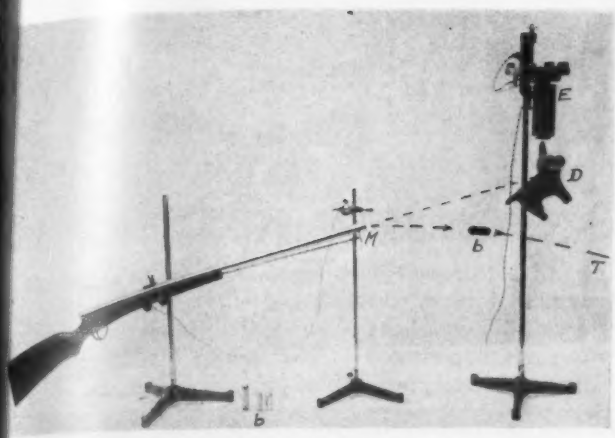


Fig. 16. A spring gun fires a wooden bullet. If gravity did not act, the bullet would hit the dog along the line *MD*. Since gravity always acts, if both bullet and dog are released simultaneously, the bullet will still hit the dog, but in mid-air on the line *MbT*.

motion. If the ball is dipped in a solution of whiting and the board on which the coördinate chart is marked is then tipped, just a little, the ball will simultaneously perform the two motions just mentioned and as it rolls over the coördinate network leaves a white trace of the whiting solution on the black board which approximates to a parabola. The trace or path over which the ball rolls may be obtained by using a sheet of carbon paper laid over a sheet of coördinate paper.

One could extend many of these illustrations to other physical processes and we would see the intimate relations between Physics and mathematical concepts. There are many instruments of measurement in which points are automatically placed on a sheet of coördinate paper and when connected form a curve as did the ball moving under the two initial forces. Thus in a recording hysteresigraph we have the composition of two vectors. The same holds true of a machine which compounds simple harmonic motions.

The equations of so many physical processes are but the equations of ellipses, parabolas, hyperbolas, inverse logarithmic spirals and circles so that the understanding of mathematics is a fundamental necessity for any advance in Physics. A knowledge of mathematics is the bottleneck to a complete understanding of Physics. However, a great deal can be learned by some simple experiments without the mathematics.

Graphical representation of physical processes is one application of mathematics to Physics. In our vector analysis it can lead us into highly involved physical phenomena.

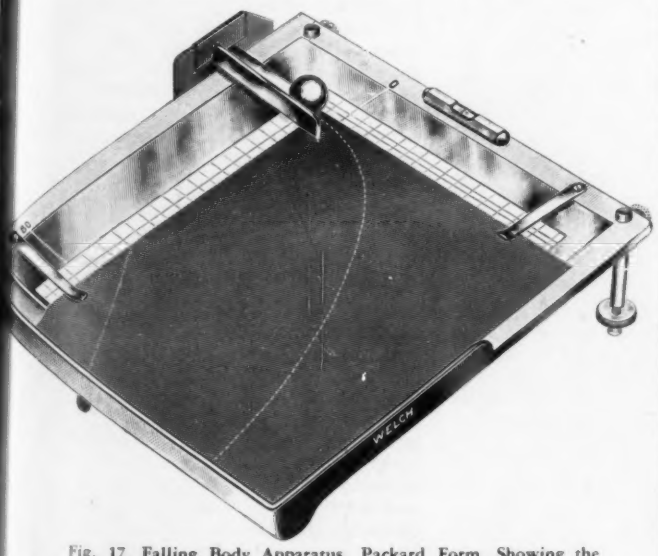
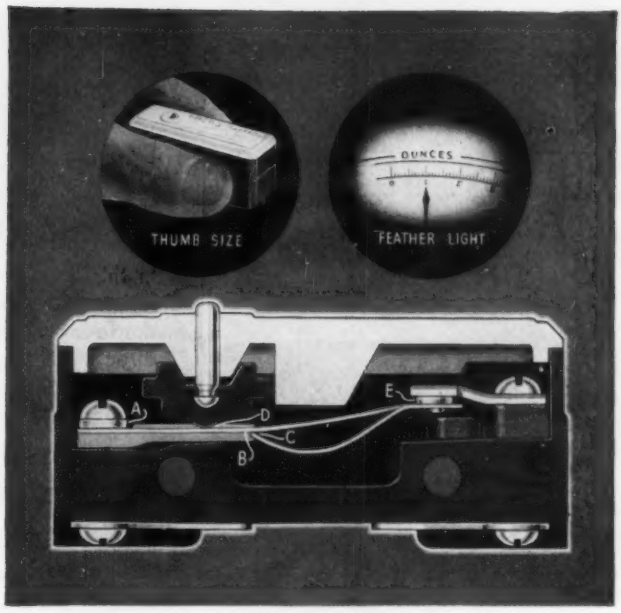


Fig. 17. Falling Body Apparatus, Packard Form. Showing the resultant path made by a body moving with uniform velocity at right angles to a motion which is uniformly accelerated. The path is a parabola. *(Courtesy W. M. Welch Scientific Co.)*



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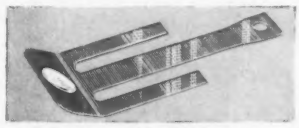

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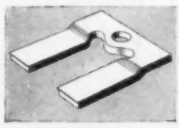

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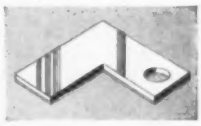

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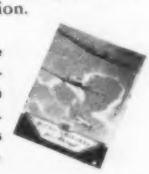

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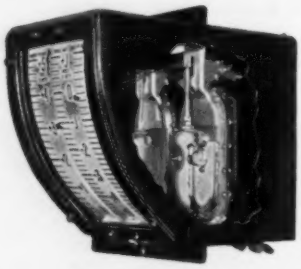

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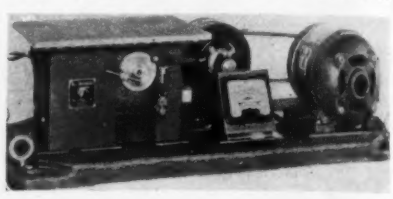
Vibration Fatigue Testing Equipment

Designed to meet the need for heavier vibration fatigue testing equipment, new tester, known as "Model 25" from its table load capacity of 25 lbs., develops a horizontal table movement with frequency of 10 to 60 cycles per second, adjustable. Table area is 12″ x 15″. Total displacement, also adjustable, is zero to 0.125″. Maximum acceleration is approximately 14 *g*. "Model 25" is mounted on a sturdy cast iron base, 19″ × 38″ with base mounting hole dimensions 16″ × 35″. Table top overall height is 11″ from bottom of base, providing adequate clearance above machine to permit handling parts larger than the table dimensions. Machine has a total net weight of 365 lbs., is powered by a one-h.p. 220-volt a-c motor, is said to embody "many refinements that contribute to highest efficiency of operation." No keys or wrenches are needed to



make an accurate adjustment of amplitude. This operation requires only ten seconds. Equipped with rugged Timken and SKF bearings, machine runs cool and will operate unattended for hours. It will not spill oil. An accurate electric tachometer is provided for frequency readings. "Model 25" is guaranteed for one year against defective material and workmanship. — *All American Tool & Mfg. Co., 1014 Fullerton Ave., Chicago, Ill.*

Synthetic Rubber Mountings

Announcement has been made that "Vibro-Insulators" (rubber mountings) can now be made using "Ameripol" synthetic rubber. These new mountings are expected to find wide application where oils, grease, paint, fatty acids or heat cause too-rapid deterioration of natural rubber used on mountings. Most "Vibro-Insulators" are designed to carry the load in shear, because rubber in shear is known to have six times the resiliency of rubber in compression. — *The B. F. Goodrich Co., Akron, Ohio.*

Decade Resistance Boxes

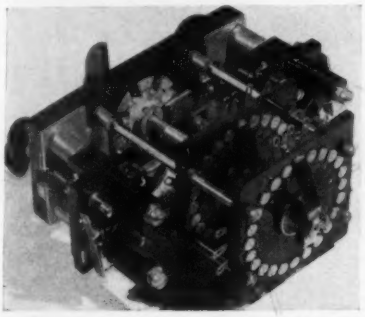
New "Type DR" D-c. resistance decades are announced in standard models with resistance ranges of 0.9 to 999,999 ohms total and with guaranteed accuracy of $\pm 1\%$ and 1.% respectively, in two price classes. All coils are of manganin wire excepting the 100,000-ohm coils of Nichrome. All coils are bifilar-wound on ceramic tubes, oven-baked and protectively-coated. Switches have self-cleaning multi-blade phosphor-bronze spring wipers. The instruments are housed in rubbed walnut cases. — *Industrial Instruments, Inc., 156 Culver Ave., Jersey City, N. J.*

Voltage Regulator

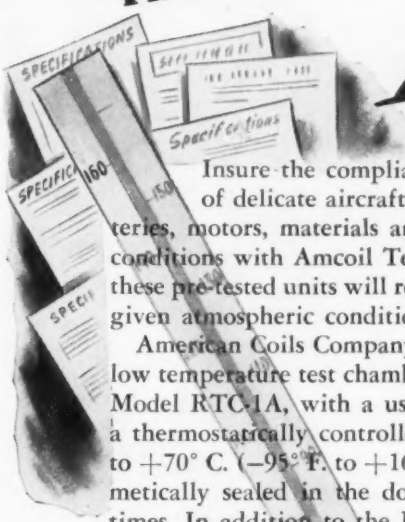
New type "Amperite" voltage regulator automatically controls the voltage delivered to a vibrator used for airplane service. With a battery variation of 20 to 30 volts (50%) voltage on vibrator is kept between 6.0 and 6.3 volts (5% variation). Included in regulator is an automatic thermal switch which turns on an auxiliary circuit 10 seconds after vibrator is started. Similar regulators can be designed to control the current and voltage applied to any load, provided that the total wattage consumed by the regulator itself is not more than 40 watts. With a 10% change in current through the regulator the voltage drop increases 200%. An ordinary Nichrome wire would only increase approximately 10%.—*Amperite Co., 561 Broadway, New York City.*

Airport Switches

For control of airport runway lighting, a new line of switches including the runway selector switch and the brightness selector switch is announced. Similar in appearance and construction, both types incorporate mechanically interlocked preset switches. Both usually are part of control desk or panel in airport control rooms and towers. *Runway selector switch* (illustrated), for selective control of runway contact lights and flood lights, consists of a two-stage rotary type switch having adequate contact capacity to handle all control requirements. Mechanically interlocked with the selector switch are two d-p. s-t. preset switches wired to permit operation of (1) the contact lights along any runway; (2) any group of flood lights; or (3) any group of flood lights and the corresponding runway contact lights, as desired. Mechanical interlocking device locks selector switch in position last selected, so that runway selection of flood and contact lights cannot be changed until selector is de-energized by turning preset switches to "off" position, thereby extinguishing contact and flood lights. Where switches are mounted on facsimile maps showing actual runway layout, switch handle can be oriented with the map to point to actual direction of plane landing or take-off. *Brightness selector switch* is a five-position switch for



Compliance
WITH HIGH AND LOW TEMPERATURE SPECIFICATIONS
Insured



Insure the compliance with temperature specifications of delicate aircraft instruments, electronic devices, batteries, motors, materials and other products under actual war conditions with Amcoil Test Chambers. Know in advance that these pre-tested units will react according to specifications under given atmospheric conditions.

American Coils Company builds a complete line of high and low temperature test chambers that will provide that insurance. Model RTC-1A, with a usable interior of 25.7 cubic feet, has a thermostatically controlled temperature range of from −70° to +70° C. (−95° F. to +160° F.). Five thicknesses of glass, hermetically sealed in the door, provide perfect visibility at all times. In addition to the RTC-1A there is a complete line of temperature test chambers, large and small, with either mechanical or dry ice refrigeration.

FOR HUMIDITY TESTING, Amcoil manufactures an individual unit which can be easily attached to their temperature test chambers.

FOR ALTITUDE TESTING, special chambers are available.

Let Amcoil Engineers advise you of the type of equipment best suited to insure the compliance with atmospheric specifications.

MODEL — RTC-1 Mechanical Refrigeration; Temperature range: −55° C. to +70° C. Usable Interior 28.7 cu. ft.

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AMERICAN COILS CO.

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RELIABLE *timing*

No. 55 Process Timer

Precious materials and valuable man hours can be saved, quality improved and production increased with dependable Stromberg timing instruments. Use them to ring signal bells, light signal lamps, start and stop electric motors, reverse drafts, open and close valves. Thousands in use today in steel plants, tool factories, rubber plants and in baking, preserving, tanning, enameling, plating and heat treating processes.

Ruggedly built for long service. Sealed to exclude dust and dirt from the mechanism. Easily set for any time interval within the dial range. A quick glance tells the interval in use and the portion of time elapsed. Dial ranges are made to fit any application.

Our engineers will be glad to study your problem and make recommendations without obligation to you.

STROMBERG TIME CORPORATION

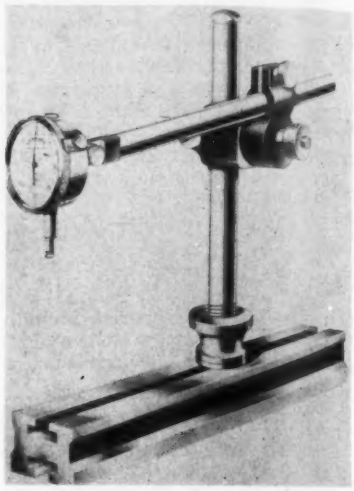
SUBSIDIARY OF GENERAL TIME INSTRUMENTS CORPORATION

109 LAFAYETTE STREET NEW YORK, N. Y.

selection of five stages of brilliancy of the runway contact lights. Located adjacent to, and mechanically interlocked with this switch, is a d-p.s-t. spring-return latch switch, with spring return to the "lock" position. This device fixes the selector switch in a definite position and locks it in the position of brilliancy last selected, until lock switch is turned to "open" and the contact lights extinguished.—*Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.*

Dial Gage Mount

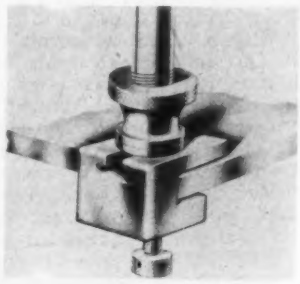
New "No. 100" dial gage mount is said to be a particularly well and rigidly constructed combination for all-around machine shop use. Its universal



swivel has individual clamping, allowing adjustment in any direction without disturbing any other setting. Adjustments are quick and positive. Its support posts are tubular, giving a larger diameter and thus making a stronger and lighter unit to handle. Main support post has a screw on top which may be removed and an extension added, giving more height when needed.—*Lombard Governor Corp., Ashland, Mass.*

Dial Gage Surface Plate Clamp

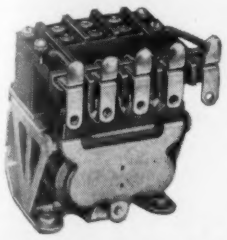
New "No. 104" surface plate clamp for dial gages is intended chiefly for general inspection use. It is designed to be used with the same main support



and cross part as in Maker's "No. 100" dial gage mount described elsewhere in these columns. This clamp is made to give definite security to the gage when one setting is required for a long period.—*Lombard Governor Corp., Ashland, Mass.*

Aircraft Relay

Developed particularly for aircraft use but said to have numerous advantages for other specialized uses, new "3PDT Type 27" Relay is said to reveal a number of interesting characteristics. A typical 3PDT Type 27 relay, "No. 12814," measures 2" × 1⅞" × 2⅛"

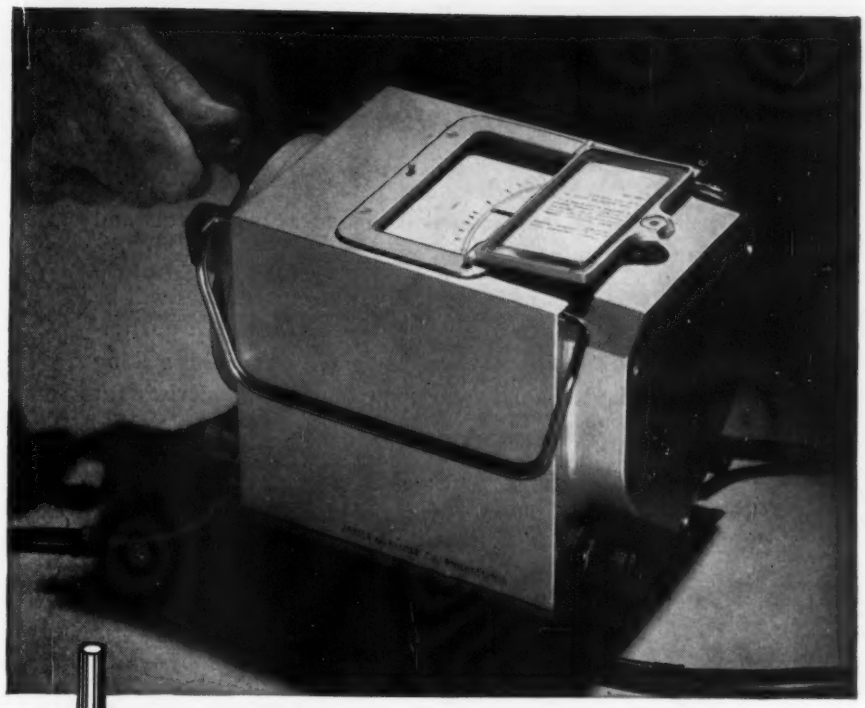


and weighs 5 oz. Its characteristics are: Acceleration up to more than 15*g*; nominal coil voltage, 12 volts d.c.; pick-up, 6.5 volts (0.92 watt) at 20° C.; coil wattage at 12 volts d.c.; 3.2 watts; contact pressure, 60 grams; contact capacity, 10 amperes at 30 volts d.c.; temperature rise 32°C., at 12 volts d.c. Free samples of this relay will be furnished interested parties if their requests are accompanied by priority of AA-4 or better. — *G-M Laboratories, 4326 North Knox Ave., Chicago, Ill.*

Kilovoltmeter

If ordinary voltmeters are employed, for measuring kilovolts, in many cases their current drain is so great that accuracy of measurements is impaired.

New "No. 760 Kilovoltmeter" meets the following specifications of an efficient instrument for measuring high voltages: (1) Low current consumption—not more than 1 milliampere. (2) Completely self-contained—all multiplier units to be an integral part of instrument. (3) Three ranges, 5, 10 and 20 kv. (4) ±2% accuracy at full scale. (5) Sensitivity of movement to be 1000 ohms per volt. (6) Rugged and portable. Multiplier unit contains maker's wire wound resistors mounted on ceramic insulators, and entire unit is enclosed in an oak case.—*Shallcross Mfg. Co., Collingdale, Pa.*



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GROUND TESTER

For Measuring Resistance to Earth of All Types of Electrical Ground Connections.

1. Direct-reading in ohms—"like a voltmeter".
2. No calculations.
3. Only one set of connections.
4. No adjustments or "balancing".
5. Covers a wide range of resistance.
6. Unaffected by stray current in the earth—either a.c. or d.c. or by polarization or electrolysis.
7. Unaffected by the exact resistance of the reference grounds.
8. Has its own hand generator; requires no batteries or other external current supply.
9. Self-contained, rugged and portable.
10. Represents only a small fraction of the cost of adequate grounding protection.

FOR SAFETY AND PROTECTION TO LIFE AND EQUIPMENT

As simple, rugged and reliable for ground resistance measurements as are our "Megger" instruments for testing insulation.

Write for illustrated Catalog 1645-I describing the "Megger" Ground Testing Instruments.

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LONG before Pearl Harbor, our plant and personnel were largely engaged in the production of optical instruments and elements for our armed forces.

Tomorrow, when victory is won, a part of our facilities will be available for the manufacture of peacetime products. A quarter-century of rigid adherence to the finest traditions of lens making will be re-dedicated to the fashioning of optical devices for safer and better living.

Today, we invite correspondence from individuals or organizations interested in the development of optical instruments or equipment for postwar business.

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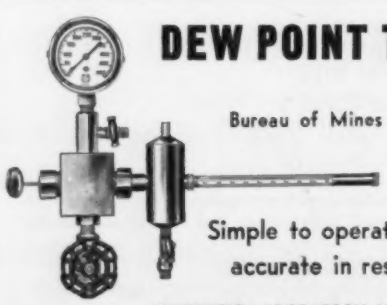

DEW POINT TESTER—TESTS UNDER ACTUAL CONDITIONS

Bureau of Mines Type

Accuracy within 0.2°F. and Dew Point temperature range as low as minus 90°F. For working pressures up to 2500 P.S.I.

Simple to operate and accurate in results.

SCIENTIFIC LABORATORY AND POWER PLANT EQUIPMENT

THE REFINERY SUPPLY COMPANY

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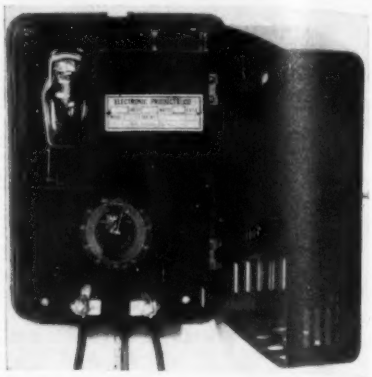
Welder Timing Controllers

New "Series A" ½-kva. and 1-kva. Welder Timer Controls have been designed to make available the same precision of timing for small welders as is



generally available for large welders. Current application is definitely and accurately controlled for any period from a half-cycle to 60 cycles. No variation of timing is possible, however slowly or rapidly the operator depresses the pedal. A single adjustment controls the timing to suit the requirements of the work. Either of the new timers may be applied to any make of welder. Supplied for either 110 or 220 volts (60-cycle unless otherwise specified). The ½-kva. model measures 9" × 6¾" × 3¾", weighs 6 lbs.; 1-kva. is 12¼" × 12¼" ×10", weighs 50 lbs. —*Electronic Products Co., 19 N. First St., Geneva, Ill.*

Multitester

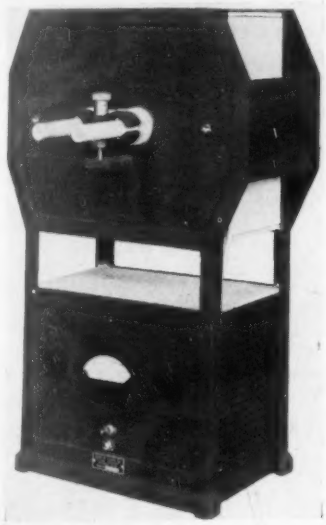
New "Model 419 Multitester" combines a-c and d-c voltmeter, milliammeter, ammeter, capacitymeter, ohmmeter and inductance meter. It incor-

porates in its design the new R.C.P. system of a-c measurements without copper oxide rectifier. A-c scales are linear with d-c scales. Sensitivity of indicator is 2,000 ohms per volt; accuracy is within 2%. Capacity-meter is direct-reading. Ohmmeter has self-contained power supply; sensitivity of low-ohm range makes it suitable for measuring contact resistance, resis-

tance of voice coils, etc. Special position provided for determining output voltage. New improved terminals replace conventional jacks. Ranges: 0-5-50-250-2,500-5,000 d-c volts; 0-10-100-500-1,000-5,000 a-c volts; 0-1-10-50-250-1,000 d-c milliamps; 0-1-5-25 d-c amps; 0-0.03-0.3-3.0-30-300 mfd; 0-100-15,000-150,000 ohms; 0-1.5-15 megohms; inductance measurements — chart reference: 0.25-1,000 millihenries, 0.25-100-1,000-10,000 henries. "Model 419" is available in three types: "419P" in maple case with cover and carrying handle. "419C" is an openface bench type with a 4½" instrument. "319V-7" is an upright tester in a crackle finish steel case with a 7¼" rectangular instrument.—*Radio City Products Co., Inc. 127 West 26th Street, New York City.*

Laboratory Furnace

New "Glotemp" high-temperature laboratory combustion furnace is for use in rapid carbon and sulphur determination of ferrous and non-ferrous

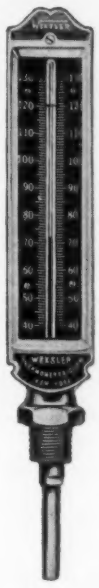


metals. Feature is short overall length of furnace without sacrificing efficiency of combustion zone. Globar heating elements are at right angles to axis of combustion tube: exposed ends of heating elements and electrical connections do not take up space along axis of combustion tube. Small combustion tube speeds up determinations because of smaller required volume of gas. Heat is confined to section of tube where it is required for rapid combustion of sample. Overall length of combustion tube recommended for this furnace is 21". Another advantage is that both ends of combustion tube are fully exposed to room atmosphere, insuring efficient cooling of tube ends to low temperature avoiding oxidation of rubber connections. Electrical accessories (transformer, voltage control, switches for regulating temperature) and the pyrometer are all securely housed in the compartment of furnace. On top of this compartment is a shelf where operator may place his tools. Furnace weighs 198 pounds; height, 31"; width, 19", furnace length, 10" and overall length, 16". Electrical input 230 or 115 volts, single-phase, 2 kva maximum consumption.—*Harry W. Dietert Co., 9330 Roselawn Ave., Detroit, Mich.*

WEKSLER

Production or Research Instruments

Weksler Thermometers are scientific, precision instruments. Their rugged construction and lasting accuracy will merit your full confidence. Red Reading and Yellow back Mercury tubes are standard in all V shape industrial thermometers. Indicating and recording thermometers are furnished mercury, vapor, or gas actuated. Dial indicating instruments are available in 4½" and 6" phenol condensate cases only, and recording thermometers in 10" chart size. There is a Weksler precision thermometer for every industrial need.



"V" Shaped Bronze Case Industrial

Thermometers and Hydrometers

Dial and Recording Thermometers

Type 124 Right Side Angle

Type 125 Left Side Angle

For information on

Dial and Recording Thermometers, send for Catalog 300 DR

For others, send for Catalog No. 115.

Weksler Thermometer Corporation

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Test Insulation the Modern Way with a MODEL B-5 MEGOHMER

NEW BATTERY-VIBRATOR TYPE

No more tiresome cranking of a hand-driven generator . . . Entirely self-contained, steady test potential of 500 volts DC, available at the touch of a switch. Direct reading in insulation resistance.

VARIOUS NEW MODELS AND RANGES

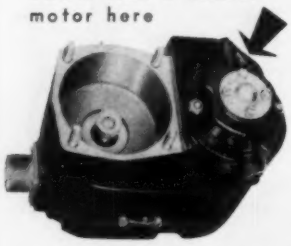
HERMAN H. STICHT CO., INC.

27 PARK PLACE NEW YORK, N.Y.

WRITE FOR BULLETIN No. 430

Motors and reducers— for Precision Applications

You'll find a Bodine motor here



"Eclipse" Propeller Governor Control with Bodine motor parts built into a section of the governor control housing. One of many specialized wartime applications.

Many instrument manufacturers have standardized on Bodine fractional horsepower motors and reducers because their operation is accurate, reliable, and trouble-free. Bodine motors are available in sizes ranging from 1/2000 hp to 1/6 hp. Speed reducer ratios range from 6:1 to 2880:1. Bodine Electric Company, 2244 W. Ohio Street, Chicago, Ill.

BODINE

BODINE FRACTIONAL HORSEPOWER MOTORS

AIRCRAFT THERMOCOUPLES

Gasket or Blind Rivet Type Thermocouples

Calibrated Lead Wires

Firewall Connectors

Army, Navy and Commercial Types

THE WINSLOW COMPANY
INCORPORATED
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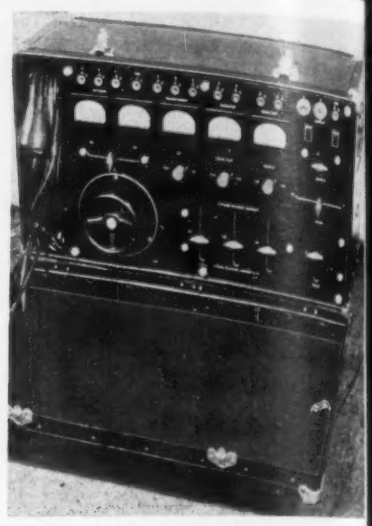
PRECISION OPTICAL ELEMENTS

IN ANY QUANTITY
MADE TO YOUR
SPECIFICATION

BOEHMKE
OPTICAL COMPANY
3737 BIRD ROAD
MIAMI, FLORIDA

Test Kit for Network Protectors

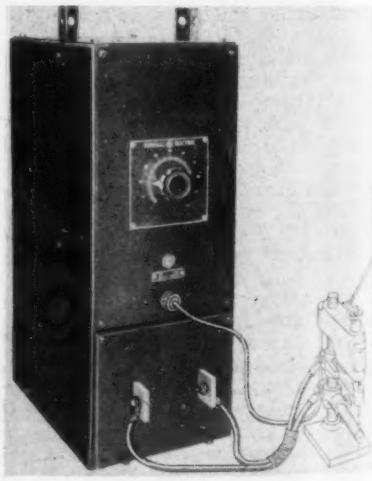
To test or check the relays of a se ondary network distribution system, usually is necessary to take them fro field to laboratory. A few power co



panies have built some field-checkin devices of their own. Now a factory built portable kit is announced fo testing the operating mechanisms a well as the relays. With this portabl unit the relays are tested at the pro tector terminals, exactly as they ar connected in service. All equipment, in cluding indicating instrumentsis con tained in a carrying case measurin about 15" × 11" × 26" and weighin 92 lbs.—*Westinghouse Elec. & Mfg. Co. East Pittsburgh, Pa.*

Half-cycle Synchronous Spot Welding Control

New electronic half-cycle synchron ous control for precise operation of re sistance-welding machines is available in two types: "CR7503-A136" which in

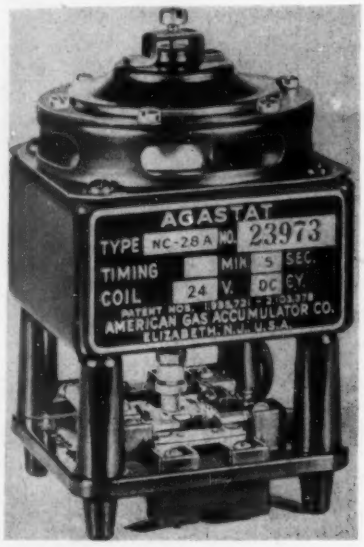


cludes also a welding transformer and is designed for bench mounting, and "CR7503-A133" which is without a transformer and is designed for wall mounting. Both types can be used either with tongs or with a suitable bench welder. Both are cabinet-mount

ed. Both utilize new "GL-415" tube said to be easily replaced; also a new circuit said to make higher-speed welding possible; and a simplified initiating circuit said to improve performance and reduce maintenance. Welding heat control is obtained by the phase-shift method; heat adjustment is by a dial on front of cabinet. Control facilitates welding of tinned wires; of 0.01" to 0.05" studs to flat surfaces with little or no indentation on the opposite surface of the metal; and spot welding of unusually thin (<0.01") pieces of stainless or mild steel, nickel, or silver to brass or bronze, with negligible oxidation or discoloration. It also makes possible the welding of low-resistance joints unaffected by temperatures above 125°C., thereby eliminating solder (saving tin) and saving 50% time. It simplifies employee training. — *General Electric Co., Schenectady, N. Y.*

Electro-pneumatic Timer

Announcement is made of re-design of "Agastat." For complete technical description of previous design see *Instruments*, June 1941, page 142. This



device is an electro-pneumatic time delay relay for making or breaking electrical circuits at pre-determined intervals. Several factors were considered in its re-design: (1) Increasing operating and functional efficiency; (2) a thorough evaluation of available materials; (3) minimizing of size and respective application-area displacement. All these were successfully accomplished. New-type "Agastat," by single screw adjustment, permits a delay ranging from a fraction of a second to several minutes. While previous model had a minimum of moving parts, new model has only "absolute essentials commensurate with its exceptional dependability." Basic design and principle of operation are retained. Instrument is said to be unaffected by heat, cold or variations in operating voltage, temperature or humidity. It weighs 1 lb. 7 oz. as against 2 lbs. 13 oz. Height is reduced from 5" to 4". Housing and component parts of heavy brass and other critical materials now have substitutions in all but actual operating mechanism.—*American Gas Accumulator Co., Elizabeth, N. J.*

There's always the Sunshine
AFTER THE STORM!

As each ray of light breaks through the dark clouds, after the storm, to fill the earth with sunshine, so each PALMER Thermometer is bravely doing its bit to bring back the sunshine of Peace to the World.

Every PALMER Thermometer is finding its place in the network of equipment needed to back the boys at war because:

1—They are extremely accurate and correctly annealed;
2—Their sturdy construction means long life;
3—The easy-reading "Red-Reading-Mercury" column eliminates error.

Just hesitate before you write that order for thermometers and you will be helping to win the war by careful selection of an instrument guaranteed to give satisfactory service.

(Catalog No. 300-D sent promptly)

THE PALMER COMPANY, Mfrs.
INDUSTRIAL, LABORATORY, DIAL & RECORDING THERMOMETERS
2511 Norwood Ave., Cincinnati, Norwood, O.—Canadian Plant: King & George Sts., Toronto

BARBER-COLMAN POWER UNIT

ON MAXON PREMIX BLOWER-MIXER

These POWER UNITS are ideally suited for industrial applications. They feature built-in limit switches and a high torque motor with gear reduction, oil submerged, for long life and dependable operation. Control action may be governed by a recording and indicating controller or other contact making control instruments. POWER UNITS are available for "on-off", floating, and proportioning modes of control, including proportioning with manual or automatic resetting.

MAXIMUM SERVICE Controls BARBER-COLMAN COMPANY MINIMUM MAINTENANCE

Write for Bulletin 4-1912
"POWER UNITS"

BARBER-COLMAN COMPANY 1202 ROCK STREET ROCKFORD, ILLINOIS

WHAT do you need in a PYROMETER ?

SENSITIVITY RESISTANCE
DURABILITY SIMPLICITY

Engelhard Direct Deflection Indicators have all these features . . . Accurate sensitivity to the most minute voltage variations due to suspension type construction . . . High resistance per millivolt and no appreciable error when used with thermocouples of different resistances and on connecting leads of considerable length . . . Sturdy construction, adapted to use under severe conditions without danger . . . So simple that instant readings may be made directly in either millivolts or temperatures by someone unfamiliar with the principles of pyrometry . . . On kilns or furnace installations, where "spot readings" are desirable—the Engelhard Rotary Switch permits separate readings from many points.

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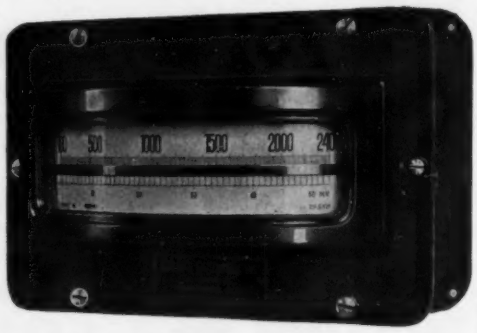

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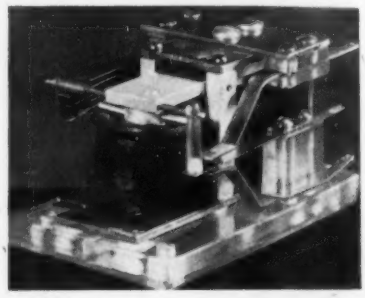

wiping action. (15) Contact springs made from cold-rolled nickel-silver stock. (16) Contacts are of palladium, welded to springs. (17) Coils are wound for both a.c. and d.c. up to 220 volts.

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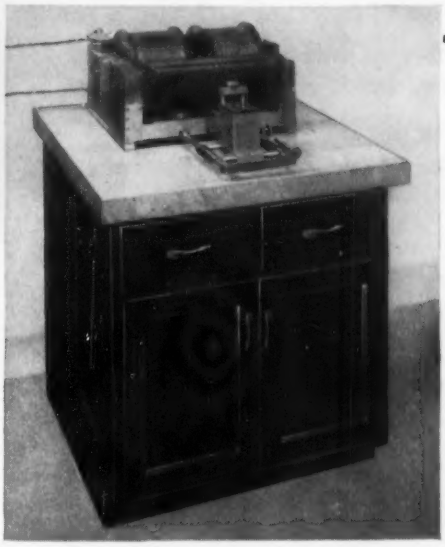

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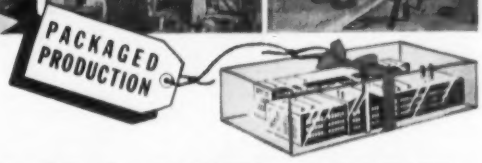

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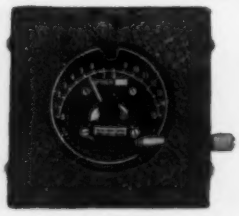

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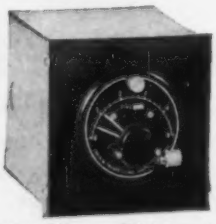

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Instruments' Book Shelf

The Electron Microscope. By E. F. BURTON and W. H. KOHL. Reinhold Publishing Corp., New York, 1942. Cloth, 6 × 9¼ inches, 233 pages. Price $3.85.

As the authors state, this little book is an introduction to the subject of electron microscopy for the reader who has heretofore not been acquainted with it. It is not a technical treatise. It begins at the beginning—perhaps a little back of the beginning—and tells in simple language how light is bent by prisms and lenses, what the eye is, what the simple and compound microscope is, what light is what the electron is. All this is illustrated by comical sketches that are particularly appealing to children: the microscope images that are customarily drawn as arrows are replaced by drawings of cats, mice, giraffes, etc.

The first half of the book covers these fundamentals, and the latter half describes the principles of all types of electron microscopes, both electromagnetic and electrostatic, emission and absorption. Only the major items of design are included, none of the details of the electric circuits or of the mechanical construction. It does not, therefore, replace the detailed instruction books that are issued with electron microscopes. While a number of photomicrographs are included to show what can be done with the various types of instruments, there is no treatment whatever of the special techniques in specimen preparation that must be used—the preparation of thin films, the dispersion of fine particles on them, and the production of thin replicas. Consequently the book is of little value to the operator of a microscope except for background and historical information. It is intended for those who wonder what the instrument is and what it can do.

—C. S. BARRETT, *Associate Professor of Metallurgy, Carnegie Institute of Technology, Pittsburgh.*

Aerial Photographs: Their Use and Interpretation. First Edition. By A. J. EARDLEY. Harper & Brothers, New York, 1942. Cloth, 6¼ × 9½ inches, xxii + 203 pages. Price $2.75.

This textbook is a primer in its field. The author states that this presentation is designed for the beginner and for the occasional user of aerial photographs. When this is thoroughly understood, the excellence of the volume becomes readily apparent. It must be realized, furthermore, that the treatment here given the subject of the use and interpretation of aerial photographs is designed primarily for students majoring in Geology. For all such, this book is so written and illustrated that it will be more than a text—it will be an elementary handbook.

For the casual civilian—the man who flies for pleasure—Mr. Eardley's book has a great deal to offer in the use of its lucid explanations of simple Geologic field methods. An application of the principles herein set forth to the terrain over which he flies will add much to his knowledge thereof, and hence to his interest and enjoyment.

The experience which Mr. Eardley has had in the teaching of this subject has enabled him to organize the material in probably the most logical and orderly fashion yet achieved. For this reason, there are few noticeable breaks in the continuity of presentation, each phase of the subject flowing easily into the next succeeding one. Particularly valuable are the exercises suggested in connection with the study of the text. It is to be noted that these exercises are suggested in such order and form that they fit together without noticeable break to form a continuous course of intimately joined and overlapping experiments.

It is most regrettable that the exigencies and necessary prohibitions incident to the War have denied the author a wider latitude in the selection of illustrations for this book. Under the restrictions thus imposed, he has done a remarkably fine job in this respect.

Studies of this character are particularly valuable in the present emergency, as groundwork for students who may later be serving in the Intelligence Division of the Army Air Force in the interpretation of aerial photographs. The author is, therefore, performing a profoundly valuable service to the nation in making available to undergraduate students in our colleges and universities in readily assimilable form, the elementary concepts fundamental to this art.

It is to be hoped that following the War, Mr. Eardley will feel constrained to revise and expand this present volume. There is much additional material which would be valuable, even to the beginner, which he might then include, and more adequate illustration for purposes of comparative training will add materially to the value of textual coverage.

—M. G. GULLEY, *Geologist, Gulf Oil Corporation, Pittsburgh, Pa.*

Manual of Aircraft Materials and Manufacturing Processes. By T. A. WELLS. Harper & Brothers, New York, 1942. Cloth. 7¼ × 10¼ inches, vii + 212 (+ 64 blank) pages. Price $3.50.

The author is Vice-President and Chief Engineer of the Beech Aircraft Corporation. His Manual is an excellent overall survey and introduction that can be of great value to the thousands of engineers, supervisors, business men and other persons now entering the field of aviation manufacturing. It will serve in only a minor way to assist those already in the aviation field, since the data presented will be more or less familiar to practically every engineer with several years of aircraft experience.

The material is presented in a straightforward and somewhat conversational style, so that a feeling of person-to-person contact is set up between reader and author. One feels, after reading a few pages, that he is spending a few hours in Mr. Wells' office, or walking with him through the plants of Beech Aircraft. The discussion is on a highly practical level. This is the talk of production people, interested in making the largest possible quantity of high-quality material at a minimum expenditure of money and time. Theoretical considerations are referred to, but not discussed in any

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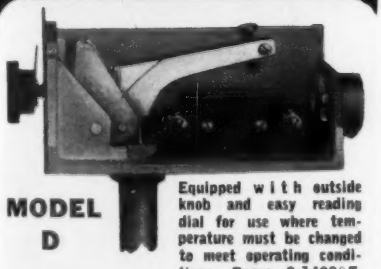

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detail. There are numerous suggestions of production methods that are excellent and well worth consideration when entering upon new phases of aircraft construction. Adherence to the general production practices described will save many pitfalls, errors and production failures.

Practically every process now in use in aircraft manufacture is discussed, in some cases in detail, but usually in a general, outline form. The information, as far as it goes, is accurate.

Rapidly changing techniques in aircraft production raise some question as to how long this manual will be of real value. However, for today it can serve a real and pressing need in educating many persons to a completely new set of problems.

—SELIG ISAACS, *Instrument Engineer, Wright Aeronautical Corp., Cincinnati, Ohio.*

Magnetic Tools and Appliances in Engineering Production. By E. MOLLOY. Chemical Publishing Co., Inc., Brooklyn, N. Y., 1942. Cloth, 5½ × 8¾ inches, 116 pages. Price $2.50.

This book deals with the uses of magnetic tools and appliances in industry. It presents clearly and concisely many applications by means of photographs, diagrams and brief descriptions. The main fields covered are Magnetic Chucks, Magnetic Detection of Flaws, Magnetic Clutches and Lifting Magnets, Magnetic Separators, Magnetic Brakes and Solenoids, and Magnets and Magnetizing.

The numerous photographs present to one a clear picture of the types of work to which the magnetic devices have been applied. A few tables and general formulae are given which enable one to make approximate calculations of the size of the unit required for a given application.

While the book treats mainly of industrial applications in England, it should be generally useful as a compact reference book covering the basic principles and applications of magnetic tools in industry.

One misleading statement appears in the Introduction on page 5, lines 35 and 36: "Magnetism is only skin deep; hence, laminations increase magnetic strength." But we should not be too critical of such a statement, as the purpose of the short Introduction is to survey only the basic principles involved in the applications dealt with in the book.

—C. K. STROBEL, *Assistant Director, Robertshaw Research Laboratory, Pittsburgh, Pa.*

Methods of Measurement. By WENDELL H. CORNETET. McKnight & McKnight, Bloomington, Ill., 1942. Paper, 6¾ × 10¼ inches, 136 pages. Price 95 cents (which includes separately-bound "Tests" described below).

From both Army and Industry sources, the reviewer heard good reports of the work done by the author as head of the Department of Vocational Science at the Huntington (W. Va.) East High Trades School. One report, for example, was that the author's Department "is supplying micrometers and other shop instruments—all of them well-made—to vocational schools all over the country." Consequently, the reviewer might be prejudiced in favor of an author who is such a successful doer of what he expounds. On the other hand, many experiences in evaluating practical text-books, over more than thirty years, have developed a sense of caution or alertness: so many successful teachers have failed so miserably as authors!

In this case it would seem that Mr. Cornetet's success as a teacher of shopwork must be due in large part to his ability as a preparer of words and diagrams for the use of students. This little book is an outstanding example of instructional material carefully prepared for that purpose. It is not divided into chapters but into thirty-four instructional units of various types—chiefly two types termed "information" units and "operative" or "assignments"

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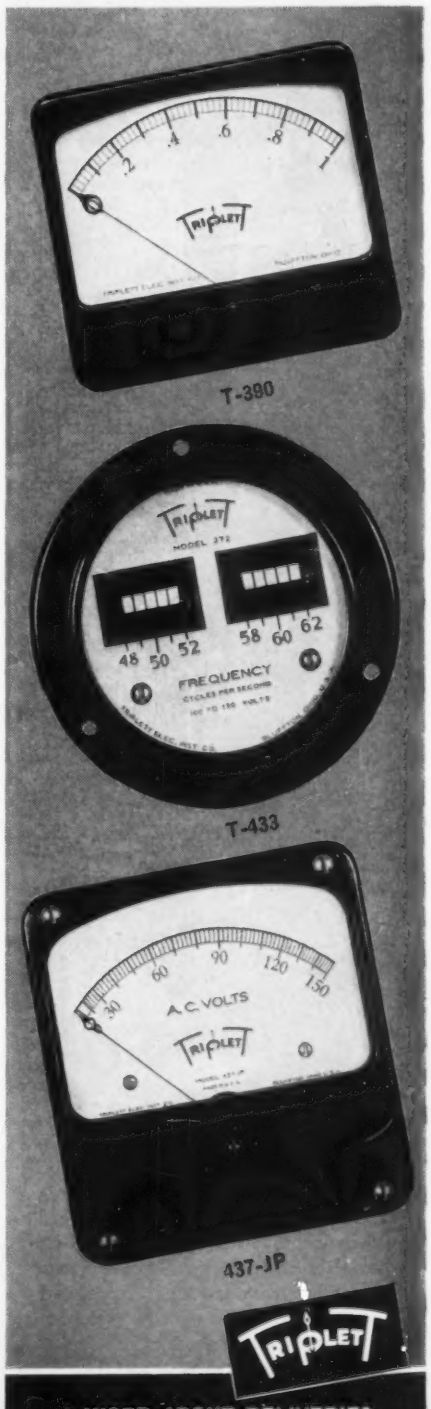

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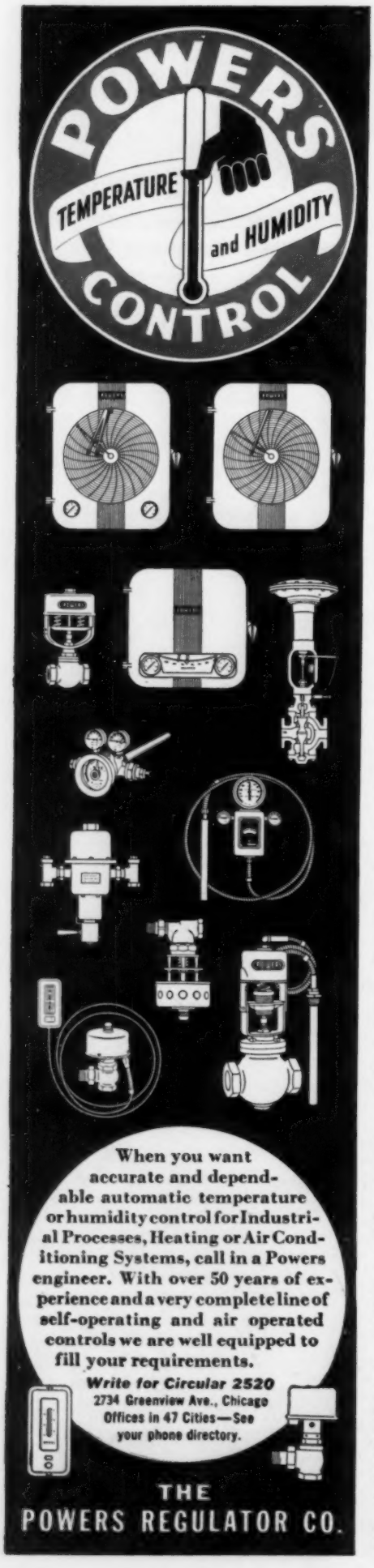
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units. It is not so much a text as a manual for use in connection with the equipment of a modern trade school. It is a combination of brief explanations (most with diagrams) and of exercise worksheets to be filled out by the student. The number of exercises at the end of each lesson is so great (up to 100 or more) that a meticulous teacher could well devote an hour to grading each student each time—especially when grading involves *measuring* the lines, angles, etc., drawn by the student.

With this book comes a 16-page supplement comprising six tests, all sheets being perforated near the fold. The titles of these tests give a better idea of the scope of the book than does the five-times longer table of contents of the book itself. These tests are: (1) Steel Rule and Calipers; (2) Geometrical Measurement; (3) Nails, Screws, Gages, Weight and Volume; (4) Density, Specific Gravity and Properties of Solids; (5) Heat and Temperature; (6) Mastery Test.

A useful feature not found in more advanced works is that in most of the lessons there is a "New Words" section between the introductory text and the exercises of the lesson. Thus the "information unit" comprises a brief but amply illustrated text and also a selected vocabulary. All definitions are brief; many are loose; some are defective. For example, in the first set (page 9) we find: "*Precision.*—Something which is accurate or exact." Worse are the duplications of "new" words but not of definitions. Examples: "*Fixed.*—Securely fastened in place" on page 23 but "*Fixed.*—Not movable" on page 31; "*Coincide*" on pages 17 and 31; "*Bevel*" on pages 31 and 42.

This defect of the "New Words" sections appears to be the result of a heroic effort to write definitions in the simplest possible English and in the fewest possible words—a neat trick when or if you can do it!

Fortunately, this defect is not observable in the brief texts on methods of shop measurements and related elementary subjects, all of which are gems of clarity and brevity. Thus, three-quarters of the chapters or "units" in this book are practically free from serious imperfections.

Unfortunately, this cannot be said of the "units" on elementary industrial physics—especially heat and temperature. Here, the admirable effort to combine brevity with simplicity of language has resulted in many inadequate statements and even in some false assertions—not only in the "New Words" but in the texts. In addition, there are inaccuracies which are not due to this admirable effort but to common mistakes. And—since Mr. Cornetet is a compiler and not an original author in this field of science—these common mistakes were probably not made by him but by the well-known authors of the well-known books on elementary physics from which he drew his heat and temperature material. Here are examples:

"When the molecules of a substance are caused to move more rapidly its temperature rises. . . . When the molecules of a substance move more rapidly, they move farther apart and the material expands." This is the false generalization found—in practically the same words—in many books on elementary physics.

"Thermostatic control devices work upon the principle of unequal expansion of different materials." Another false generalization. Why do not these authors say "*Some* thermostats utilize the differential-expansion principle."?

"In measuring higher temperatures, as in heat treating ovens, etc., thermocouples *and* pyrometers are used." A common mistake which can only be attributed to the fact that the distinguished authors of the well-known texts became careless when they dealt with industrial matters.

"*Pyrometer.*—An electrical instrument used for measuring high temperatures." This one of several instances where the definition is incorrect because it is too long. Strike out "electrical" and it becomes correct.

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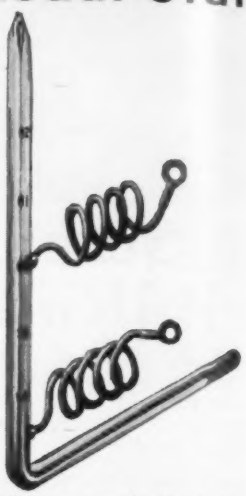

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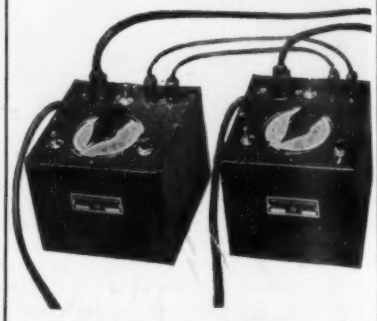

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"Thermostat." — An automatic device for controlling temperature by the expansion of materials." Another case of over-length: strike out "by the expansion of materials" and it becomes correct.

"Pyrometric." — Having to do with the measurement of heat." The old confusion between heat and temperature! This, of course, is a definition of "calorimetric."

"Thermocouple." — Two dissimilar wires welded together, used with a pyrometer in measuring heat." This is almost as bad as the schoolboy's definition of the lobster as "a red fish that swims backwards"—which his teacher marked "Correct except that the lobster is not red, is not a fish and does not swim backward." This is in the "New Words" on page 110. On page 113, the explanation preceding the experiments with thermoelectric apparatus begins with a false assertion which is even more harmful because it is the kind of pseudo-science which is difficult to drive from the minds of boys and girls when they become men and women: "When two wires of different metals joined together at one end by welding, are heated, a small current of electricity is generated."

The definitions and explanations of fusion cones are defective in omitting that cones indicate the combination of *duration* and temperature. The only name mentioned is Seger and it is always misprinted as "segar" with an *a* and a small *s*. Moreover, this uncapitalized noun is placed between quotation marks for no apparent reason.

In fact, all "units" on "Heat and Temperature" (pages 106-126) are so defective that, in this reviewer's opinion, they should not be used in vocational training programs. Nor should Test No. 5 in the 16-page supplement be used for giving written examinations on heat and temperature: there's too much risk of unjustly flunking the students who would give the correct answers!

On the whole, an excellent little book on shop measurements and related subjects has been spoiled by being expanded into a book on shop measurements and related subjects and industrial physics.

To the student who has completed the course, this book serves as a refresher and reference of great practical usefulness in his or her work in industry. By the same token it should serve older technicians and engineers as a refresher and reference on shop measurements and elementary related subjects. —M. F. BEHAR

Astronomy, Maps, and Weather. By C. C. WYLIE. Harper & Bros., New York, 1942. Cloth, 6¼ × 9½ inches, x + 449 pages. Price $3.00.

This book was prepared at the request of the Army Air Corps Flying Training Command to meet the needs of prospective pilots, navigators, and bombardiers. "It stresses familiarity with the constellations and brighter stars; a conception of the Earth in space; the motions of the Earth; the fundamentals of time, with practice in the use of navigational time-pieces; the determination of longitude, latitude, and Sumner lines; map construction and map reading; and the principles of meteorology, particularly weather forecasting from immediate observational data."

The book not only attains its military objective, but presents the subject matter clearly and in a style that holds the attention of the reader. The treatise will prove to be interesting and informative to both the professional and layman.

An examination of some ten well-known texts of astronomy showed that only two have the word "weather" in the index, and these texts merely state that the moon is without appreciable effect thereon. No other occupation is more dependent on the weather than astronomy is, but modern astronomical texts entirely avoid the subject. This is perhaps because, for much of the earth's surface, we cannot as yet predict whether we shall be able to observe the

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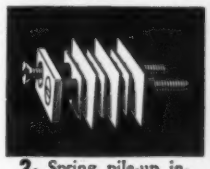
1. Contact springs employing any of the forms illustrated can be furnished.

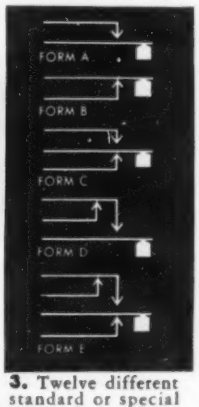


2. Spring pile-up insulators of heat treated Bakelite which permit punching without cracks, have minimum cold flow and low moisture absorption content. Assembly locked together under hydraulic pressure. Withstands heavy breakdown tests.

4. Spring bushing insulators are Bakelite rod made by a patent process. Strong, hard, long wearing. Essential where heavy contact pressures are employed, where vibration exists, or heavy duty service is desired.

5. Armature assembly single or double arm. Has stainless steel shaft, operating in a marine brass yoke. Heel piece, coil core and armature are magnetic metal carefully annealed. Designed for d.c. service.

6. As illustrated, relay has octal base plug mounting for easy service and replacement. Other mountings, and Bakelite or metal cover, can be supplied.



3. Twelve different standard or special types and sizes of contacts can be furnished. Contacts are overall-welded to nickel silver springs. Sizes range from .062" silver, rated one ampere, 50 watts, to .1875" tungsten, rated four amperes, 500 watts.

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next minimum of Algol; or whether, if the sky is clear, the atmospheric steadiness will be such as to allow us to measure close double stars. We still must wait and see. But the airman must know as nearly as possible what sort of atmospheric conditions he will have to fly through, or avoid, and what the conditions will be at his journey's end—when he gets there. The chapters on weather introduce the navigator to the fundamentals and to many of the details necessary to make proper predictions. While written for the navigator, the general reader will find these chapters readable and instructive. The reviewer welcomes the union of astronomy and weather after a separation lasting over a hundred years. The astronomical sections of the book cover the subject rather fully, in a manner readily grasped by the beginner. Particular stress is laid upon the details required by the navigator.

For a work which necessarily had to be prepared in haste, there are few cases of lack of clearness, and few points upon which anyone could differ with the author. Since space does not permit one to enlarge on the many excellent features of the work, it might give a false impression to mention in detail the few changes which might be made with profit in a second edition.

The book is well illustrated by carefully chosen reproductions and drawings. In fact, the mere perusal of the 197 illustrations would give one a fair idea of astronomy, maps, and weather. In the reviewer's opinion, no text in a generation has better met the conditions imposed upon it than has this one by Professor Wylie.

—KEIVIN BURNS, *Astronomer, Allegheny Observatory, Pittsburgh, Pa.*

Theory and Applications of Electron Tubes. By HERBERT J. REICH. McGraw-Hill Book Co., Inc., New York and London, 1939. Cloth, 6 × 9¼ inches. xviii + 670 pages. Price $5.00.

A vast body of literature dealing with the electron tube has been disseminated in the form of test-books and articles in periodicals in fields ranging from physics and engineering to servicing of appliances. This scattering of literature has been combined in an interesting and auspicious manner in Dr. Reich's volume.

The text is written clearly and with a broad grasp of the subject which should make it invaluable to the student as well as to the experienced engineer, especially in those cases where the electron tube has only been of passing interest to the technician who has specialized in other fields. For the training of students it should fill a badly-felt need. The book is practical in tenor, yet it covers sufficient theory so that the reader is led to a full understanding of the principles underlying the various phenomena which must be understood before electron tubes may be applied intelligently. Mathematical aspects of the subject are treated in a manner to make the demands upon the reader's mathematical knowledge as mild as possible, consistent with the demonstration needed.

To the non-specializing engineer or physicist, the volume should be invaluable as a means of presenting the electron tube apparatus as a new technical tool.

The scope of the effort in the vast breadth of information contained in the volume, as well as the author's ability of extracting the essence of a difficult subject and presenting it in a simple, straightforward manner, should make the volume a "Must" in every engineer's technical library.

As a contribution to the art (notwithstanding excerpts contained therein from previously written literature, and therefore in one sense a compendium) the book recommends itself to all library collections. Dr. Reich dedicates this book to the scientists and engineers upon whose work it is based, and such recommendation is unhesitatingly concurred in by the reviewer, especially since most of the data contained in

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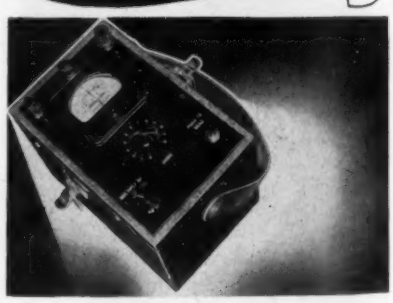

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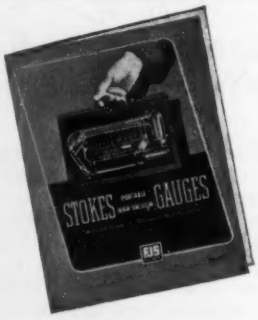

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the volume have been used by the author in the curricular courses at the University of Illinois.

Chapter I presents in a concise and clear manner with a deletion of mathematical analysis, the physical concepts underlying the electron tube *per se*, covering such matter as simple terminology and definitions of such subjects as: Ionization, Excitation Potentials, Deionization, Emission, both primary and secondary, Work Function and an Electron Tube classification in the broad sense. A well-chosen bibliography on these, in the form of footnotes and at chapter end, is also presented.

The important subject of Thermionic Emission, on which the operation of the majority of electron tubes is dependent, is treated in Chapter II. Starting with Richardson's theory of the emission of electrons from hot bodies, and with passing note of Richardson's equations for saturation current as a function of temperature, emphasis is laid upon underlying effects without burdening the reader with mathematical exposition. Emission sources ranging from pure metals to coated materials are well treated, while effects of gas upon electron tube operation are covered in abbreviated form. Childs' Law for relating anode current and voltage is treated in mathematical and graphical form in a manner calculated to give the reader a secure grasp of the subject. The chapter ends with a good bibliography, as well as voluminous footnotes for further reference.

Chapter III, in the reviewer's estimation, is probably of major interest to the vacuum tube engineer, inasmuch as a thorough exposition is set forth on the grid-controlled high vacuum tube. It should be realized that the greatest single advance in the development of vacuum tubes was the introduction by DeForest (1907) of a control electrode (grid) between the cathode (emitter) and plate of the two-element tube. Theory of Grid Action is well covered, while mathematical derivation in final form, as well as reference to the voluminous literature is well presented. Tube factors such as: Amplification Constant, Electrode Conductance, Transconductance, etc., are explained and illustrated with simple mathematical and graphical coverage.

The table of Standard Symbols, based upon accepted standards in the art, on pages 64 and 65, Chapter III, is well chosen. For the communication engineer, exposition on the use of the series expansion in tube function is of major importance and is treated in a brilliant manner. A brief list of problems for the student terminates the chapter, with sufficient bibliography in the form of footnotes for further study in literature.

Chapter IV, on the analysis of vacuum tubes, primarily for the communication engineer, should be studied assiduously for necessary understanding of vacuum tube application problems in communication fields. Problems are presented at the end of the chapter, as well as a noteworthy bibliography on the Theory of Harmonic Production in Tubes and Harmonic Analysis.

Chapters V, through X, cover in a concise and interesting manner the subjects of Modulation and Detection, to the Design of Amplifier and Oscillators. Underlying theory, therefore, is treated in a noteworthy manner, which should be highly commendable to communication engineers. The latter portion of Chapter X, dealing with such oscillators as magnetostriction, relaxation, Barkhausen-Kurz, magnetron and ionic types are of interest to the communication engineer who is interested in the newer communication techniques. Graphical and mathematical analyses in simple form are typical of this well-written text and a fine termination of these chapters with problems and supplementary bibliography are to be noted.

Coverage of the increasingly more important field of Electrical Conduction in Gases in Chapter XI, and the application of such gaseous conduction technique to Glow and Arc discharge tubes and circuits as described in Chapter XII, recommends this portion of the text to the engineer and

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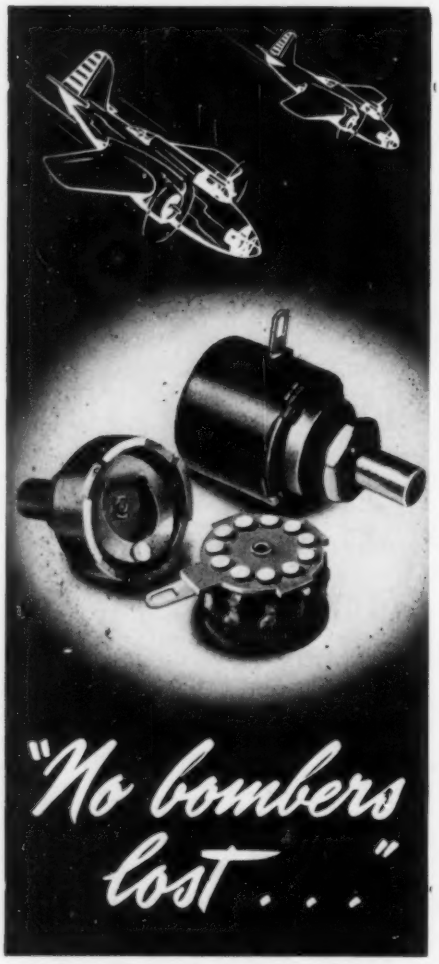

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physicist interested in the application of electron tubes for industrial and laboratory process control. This Chapter XII, with its voluminous treatment of a complex and industrially important subject, cannot be too much commended. It is well written, with adequate illustrations and sufficient theoretical coverage to give the reader a good grasp of the subject as well as sufficient bibliography to allow the student to familiarize himself with the literature.

A text of this nature would hardly be complete without some exposition of the photoelectric cell or light sensitive tube, which has become such an important industrial tool. This subject is covered in a concise and rather brief manner in Chapter XIII.

Power Problems and Supplies, Chapter XIV, are well treated and recommended for supplementary reading in the design of electron tube apparatus.

Chapter XV, the last chapter of the volume, is a brilliant compendium and description of electron tubes as integral portions of measuring devices, as exemplified in vacuum-tube voltmeters and ohmmeters. The cathode-ray oscillograph, constant measurement bridges, as well as an interesting coverage of the subject of harmonic analyzers and measurement procedure, should recommend this chapter universally to the laboratory technician, as well as to the practical engineer. Where needed, a graphical and mathematical exposition is presented sufficiently to fulfill the intent of the author to delete complex material.

The appendix containing charts and tables as well as a conventional tabulation of characteristic data for typical tubes is rather sketchy, and could be amplified and enlarged with considerable advantage to the reader.

A fine authors' index, subject index and symbol index, attests to the understanding of Professor Reich of the student's problem.

The book is adequately illustrated and printed in fine clear form, while paper and bindings are of fine texture and workmanship. It is truly a worthy accretion to the Technician's shelf.

—THEODORE A. COHEN, *Chief Engineer Wheelco Instruments Co. Chicago, Ill.*

Structure and Properties of Alloys. First Edition. By R. M. BRICK and ARTHUR PHILLIPS. McGraw-Hill Book Co., Inc., New York, 1942. Cloth, 6¼ × 9¼ inches, xiv + 227 pages. Price $2.50.

The authors of this text point out that modern developments in physical metallurgy are the results of "Systematic studies of the relationship between composition, structure and properties of metallic substances." They then proceed in a clear and concise manner to demonstrate how phase diagrams are used to make those studies logical and simple. Non-equilibrium and other miscellaneous treatments such as chill casting, quenching, and cold working are also discussed.

Chapter headings are: Requisite Tools of the Metallurgist; Commercially Pure Metals; Cold-Working and Annealing; Solid Solutions: Copper-Nickel and Other Useful Systems; Eutectic Alloys: Lead-Antimony System: Bearing Metals; Age-Hardening: Cast and Wrought Aluminum Alloys; Phase Transformations: Copper-Zinc Alloys; Iron-Carbon Alloys: Normalized and Annealed Steels; Structural, Forged and Cast Steels; Theory of Heat Treatment of Steels; Heat-Treated Automotive and Tool Steels; Cast Irons; Monotectics; Sintered Metal Powders; Generalizations.

Most of the material is handled in a refreshingly original manner and is accompanied by a multitude of new and well-explained photomicrographs. No budding metallographer should be without a good book on the technique of sample preparation and this little book which shows him how to interpret the structures he develops.

—MALCOLM F. HAWKES, *Instructor Carnegie Institute of Technology, Pittsburgh, Pennsylvania.*

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Instrument Societies

ATLANTA

We didn't give away dishes or have "Bank Night" but we did have three movies at the February meeting of Georgia Society for Measurement & Control held February 22.

Paul Wier, Supt, of Atlanta Water Works Purification Plant, showed a film entitled "New Steel Water Transmission Line to Bell Bomber Plant," made for and owned by Dixie Culvert & Metal Co.

Through the courtesy of the Bell Aircraft Corp. their film "Cannons on Wings" was seen and heard. This is a fine bit of photography and in an interesting manner takes one through a typical Bell plant.

Extra feature was the Office of War Information's picture, "The World at War." This traces the war from the time China was attacked through Pearl Harbor, and ends with the first major reverses the German army met at the hands of Russia.

—DON BEACH

BALTIMORE

Perry A. Borden, Patent Engineer of the Bristol Company, was the speaker at the February meeting of the Baltimore Industrial Instrumentation Society. His subject was "Modern Electric Telemetering." He dealt with the development of telemetering from some of its earliest forms and applications to present usage. He closed with a brief picture of the possibilities of telemetering after the war, when the developments now restricted by the war are available for industrial use.

At our March meeting there will be two talks. Andrew I. Dahl, Associate Physicist of the Bureau of Standards, will speak on the "Stability of Base Metal Thermocouples," and Mr. Reimuller of the Toledo Scale Co. will present a short paper on "Scales."

At the present time, we are rewriting our constitution, having found that it was necessary to make extensive revisions, due to circumstances which could not be foreseen last fall.

—FRED PULLEN

CHICAGO

A large and enthusiastic audience attended the February meeting of the Chicago Society for Measurement & Control held on Monday evening, February 1st, at Phil Smidt's Restaurant in Hammond, Indiana.

J. M. Brashear, Combustion Engineer of the Inland Steel Company, spoke on "Combustion Control Instrumentation and Important Factors Relative to Operation." Specifically, he discussed the use of combustion control as applied to open hearth furnaces. He pointed out that while some of the results obtained were not entirely satisfactory, this could be be attributed to both the severe service to which the instruments were subjected as well as the incomplete knowledge of the technique of open hearth operation.

An interesting and informal discussion followed the speaker's paper.

—J. A. RIGGS

NEWARK

Instead of the previously-scheduled subject and speaker at our February meeting, Smith R. Webb of the Paterson Aircraft Instrument School gave an interesting account of the development of aircraft instruments, starting with the time when the main flight instrument was located in the seat of the pilot's pants. The many charts he brought with him enabled those interested to study the details of many instruments.

At a meeting of the Executive committee on February 22, a shift in the committee chairmen was effected. Since Mr. Thomas has completed the Constitution, he was asked to become Chairman of the Membership Committee and Mr. Moore became Chairman of the Program Committee. Mr. Schweizer relinquished the Program Committee but retained the Arrangements Committee.

The March meeting featured a talk on "Electrically-operated Proportional Control Systems" by John C. Emmerline, field engineer for the Leeds and Northrup Co. Mr. Emmerline first described how throttling control is obtained in an electrically-operated controller. He then illustrated how the proportional range is adjusted. By further expanding the simple wiring diagrams, droop correction (or reset) was shown. As finally developed, the electrical controller had fully-adjustable throttling range with adjustable automatic droop corrector. In the question period following the talk, it was brought out that in the electrical controller the throttling range and reset adjustments were entirely independent of each other, while in pneumatic controllers, adjustment of the reset usually affects the throttling range.

—BOB GRAY

NEW YORK

Forty-three attended the dinner which preceded the February 23rd meeting which had an attendance of 65.

Our Vice-President, Dr. P. G. Weiller gave us a thought-provoking discussion on the problems of the seller and buyer of instruments. One of Dr. Weiller's principal contentions was that most instrument manufacturers tend to overemphasize the accuracy of their instruments and to underemphasize the necessity for proper working conditions for the instruments.

Few discussions before the Society to date have provoked such a variety of spirited comments by the membership, and Dr. Weiller was kept busy for almost an hour answering the questions put to him. All seemed agreed that the manufacturer and the user must strive in closest coöperation to bring the performance of instruments in the field as close as possible to their optimum performance in the manufacturer's laboratory.

—BOB FARNHAM

PHILADELPHIA

An excellent talk on "Time Controls in Industry" was given at the regular meeting on February 17 by John C. Whiddett of the Automatic Temperature Control Co. He pointed out the standard timer equipment available and every-day applications of the same, along with such special timers as used in the chemical, oil refining and steel industries.

At the conclusion of the talk a spontaneous round of applause marked the appreciation of the speaker's subject. A discussion followed and some rather unusual timer applications were brought to light.

Thirty members and guests attended the dinner, followed by a brief meeting of the Executive Committee. The meeting attendance was sixty-five.

—GEORGE HAMMER

METER ASSOCIATIONS

Subscriber J. C. Groenewege, Wilmington, Calif., reminds the editor of *Instruments* that—

In Southern California we have a group that has been organized since 1924. It is the Southern California Meter Association. Members are mostly employed in the oil and gas industry. Meetings are held on the third Thursday at Rio Hondo Country Club (6:30 P.M.) The organization's address is Box 85, Hyde Park Station, Los Angeles.

Thank you for this opportunity of mentioning the SCMA on this page. This page *belongs* to organizations—which means that we do not take the liberty of printing news and notices unless we receive them, as in this case. We know that there are metermen's associations (electric, gas, oil, etc.) in several regions. Their Secretaries or Publicity Chairmen are once again invited to make use of *Instruments* without charge.

—M. F. Behar, *Editor*

INSTRUMENT SOCIETIES CALENDAR

City	Society	Secretary	Date	Place	Subject	Speaker
Atlanta	Georgia Society for Measurement & Control	D. D. Beach, P.O. Box 4569, Atlanta, Ga.	Mar. 22[A]	Blue Flame Room, Atlanta Gas Light Co.	(an electronic subject)	(To be announced)
Baltimore	Baltimore Industrial Instrumentation Society	Fred Pullen, Bethlehem Steel Co., Sparrows Point, Md.	Mar. 19[D]	Maryland Academy of Sciences	(Two subjects and two speakers—see above)	
Chicago	Chicago Society for Measurement & Control	Carl Hope, 2626 W. 31st Blvd., Chicago	Apr. 5[B]	St. Clair Hotel	Measurements of the Magnetic Properties of Metals	Kenneth L. Scott, Western Electric Co.
			May 3[B]	St. Clair Hotel	Substitutes for materials used in instrumentation	(To be announced) Tech Chairman, E. C. Rieger
Hartford	Hartford Society for Measurement & Control	Stephen J. Zelle, Whitney Chain & Mfg. Co., Hartford, Conn.	Apr. 20[D]	Hartford Electric Light Auditorium	Magnetic Inspection	George L. C. Dehn, Magnaflux Corp.
Newark	New Jersey Society for Measurement & Control	R. F. Robey, 409 Orange Ave., Cranford, N. J.	Apr. 6[C]	Public Service Terminal Restaurant	Time Sequence Controllers	J. C. Whiddett, Automatic Temperature Control Co.
New York	New York Society for Measurement & Control	R. K. Farnham, 545 Fifth Ave., N. Y. C.	Mar. 30[B]	Churchill's Terminal Restaurant	Instrumentation in the Weather Service	C. H. Colvin, Dir. Guggenheim Aero Sch., N.Y.U.
			Apr. 27[B]	Churchill's Terminal Restaurant	Magnetic circuits for instruments and control devices	H. C. Roters, Dir. Research, Fairchild Aviation Corp.
			May 25[B]	Churchill's Terminal Restaurant	Special Instruments in the War	R. J. S. Pigott, Chief Engr. Gulf Research & Dev. Corp.
Philadelphia	Philadelphia Society for Instrumentation	George Hammer, Foxboro Co., 701 Otis Bldg., Phila., Pa.	Apr. 21[D]	Engineer's Club	Automatic Control of Industrial Processes	J. C. Peters, Leeds & Northrup Co.
Pittsburgh	American Society for Measurement & Control	L. M. Susany, c/o Carnegie Institute, 4400 Forbes St., Pgh.				

[A]Meeting at 7:30, no dinner. [B]Dinner at 6:30, meeting at 8. [C]Dinner at 7, meeting at 8. [D]Meeting at 8, no dinner.

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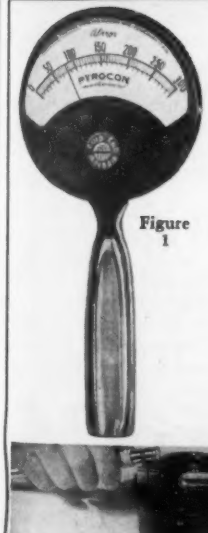

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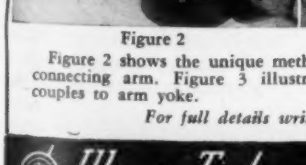

Figure 2

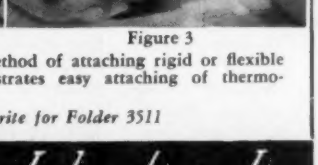

Figure 3

Figure 2 shows the unique method of attaching rigid or flexible connecting arm. Figure 3 illustrates easy attaching of thermocouples to arm yoke.

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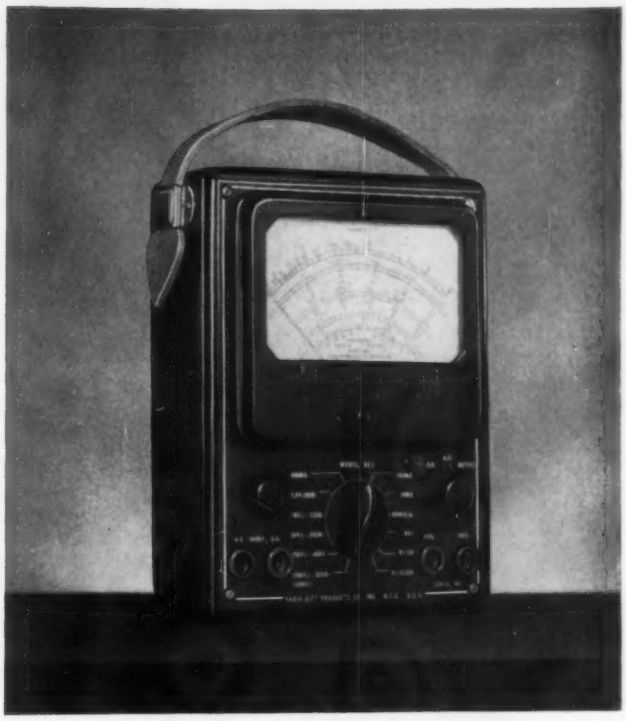

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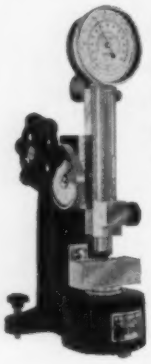

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K-91 **Type U Test Set.** Catalog E-53-441(1), 8″ × 10½″, 8 pages, of special interest to telephone and other communication engineers is a newly-revised catalog which describes the well-known Type U Test Set. This sturdy, portable Wheatstone bridge is designed especially for communication purposes in measuring resistance and capacitance. It is best adapted for locating faults on telephone and telegraph cables, for identifying faulty wires in a cable, for measuring conductor resistance, for locating grounds and crosses by Murray, Varley and Hilborn loop tests, and for locating opens by capacitance tests. Leeds & Northrup Company, 4934 Stenton Ave., Philadelphia, Pa.

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K-98 **Photoelectric Glossmeter.** Bulletin, 8½″ × 11″, 4 pages describes an instrument for measuring specular gloss of paints and varnishes, ceramics, paper, and machined or polished surfaces. It is suited to register changes in specular gloss as a result of age, wear, abrasion, exposure to moisture, heat, light, vapors, or sprays. Photovolt Corp., 95 Madison Ave., New York, N. Y.

K-99 **Modern Precision.** The Autumn 1942 issue of this house organ has a number of instrument application stories in the process industries, ceramics industry, metals industries, oil industry, power plants, research, teaching and testing. Leeds & Northrup Co., 4984 Stenton Ave., Philadelphia, Pa.

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K-102 **Photoelectric Relays for Automatic Control.** Catalog GEA-1755E, 8″ × 10½″, 4 pages describes the relays, light sources and accessories. General Electric Co., Schenectady, N. Y.

K-103 **Wheelco Comments.** The January issue of this house organ is devoted to the use of temperature controls to flexible glass manufacture. Wheelco Instruments Co., Harrison and Peoria Sts., Chicago, Ill.

K-104 **Thermocouple Tubes.** Circular NS(1), 8″ × 10½″, 2 pages shows present (Jan. 1943) recommendations for protecting tubes. Leeds & Northrup Co., 4984 Stenton Ave., Philadelphia, Pa.

K-105 Test Scale. Circular Page No. 1011, 8½ × 11", 2 pages illustrates a fuel or lubricating oil test scale used also for regulating the flow-rate of any fluid by weight without regard to viscosity or volume changes due to variations of temperatures of the fluid. Kron Co., Bridgeport, Conn.

K-106 **General Radio Experimenter.** The February issue of this house organ has a continuation of "The Noise Primer". The subjects covered are: 1. The decibel —what it is in sound measurements and 2. How to use a sound-level meter. General Radio Co., 30 State St., Cambridge A, Mass.

K-107 **Westinghouse Research.** The January 1943 issue of this periodical published bi-monthly by the Westinghouse Research Laboratories has a number of brief stories on research. The lead-off article is entitled "Spray Studies May Improve Engine Performance." Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

K108 **Inverter Ballasts.** Bulletin GEA-3907, 8" × 10", 2 pages, features d-c. and a-c. ballasts for fluorescent lighting of aircraft instruments and indicators. General Electric Co., Schenectady, N. Y.

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K-112 **Ohmite News.** The February issue of this house organ has a lead article on Michael Idvorsky Pupin as well as a number of other interesting items. Ohmite Mfg. Co., 4835 Flournoy St., Chicago, Ill.

K-113 **Automatic Control Equipment.** Bulletin 720, 8½" × 11", 4 pages describes magnetic contactors, remote control switches, and automatic transfer switches. Zenith Electric Co., 152 W. Walton St., Chicago, Ill.

K-114 **Strain Gage.** Bulletin 171, 6" × 3½", 24 pages, describes the SR-4 strain gage and illustrates a number of applications. Baldwin-Southwark, Nicetown, Philadelphia, Pa.

K-115 **Tips on Making Transmitting Tubes Last Longer.** Form 1F8014, 5" × 7½", 12 pages, gives a number of rules for making tubes last longer. Radio Corp. of America, Camden, N. J.

K-116 **Plug Gages.** Bulletin 42, 8½" × 11", 12 pages, illustrates and lists gages ranging from .030" to 4.500". United Precision Products Co., 3524 W. Belmont Ave., Chicago, Ill.

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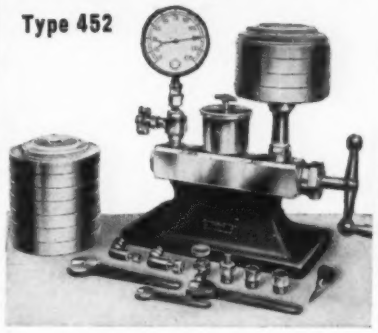

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